53,138,160

Designing Systems That Adapt to Their Users

Tutorial presented at CHI 2001

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EXHIBIT B

Overview

1 **Table of Contents (1)**

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Table of Contents (2)

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Agenda

Morning

Introduction

9:00–9:15 Lecture

Functions (1)

9:15–9:40 Lecture and Demos

9:40–10:10 Workshop 1

Functions (2)

10:10–10:30 Lecture and Demos

Coffee Break

11:00–11:10 Lecture and Demos

11:10–11:40 Workshop 2

Properties

11:40–12:05 Lecture

12:05–12:30 Workshop 3

Lunch break

Afternoon

Input

2:00–2:20 Lecture

2:20–2:45 Workshop 4

Inference

2:45–3:05 Lecture

3:05–3:30 Workshop 5

Coffee break

User Studies

4:00–4:25 Lecture

4:25–4:55 Workshop 6

Synthesis

4:55–5:30 Workshop 7

Instructor Biography

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Anthony Jameson obtained a BA in Philosophy at Harvard College and a PhD in Psychology at the University of Amsterdam. He has conducted research and published on various aspects of user-adaptive systems since the early 1980s, at the University of Nijmegen (the Netherlands) and at Saarland University and the German Research Institute for Artificial Intelligence (DFKI), both in Saarbrücken (Germany). He has taught courses and supervised projects in human-computer interaction at these universities and at the International University in Germany.

He was program co-chair of the Sixth International Conference on User Modeling (UM97).

Currently he is a senior researcher at DFKI and adjunct professor of human-computer interaction at the International University in Germany. In addition to conducting research, he works with German companies on practically oriented projects involving interface design and the personalization and usability evaluation of commercial web sites. Further information, including links to many electronically available publications, is available at the web homepage http://dfki.de/~jameson/.

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Objectives of the Course

1. Become acquainted with a representative sample of recent user-adaptive systems
   - These can serve as reference points for later thinking about such systems
2. Learn about the main high-level decisions that need to be made when designing a user-adaptive system
   - For each such decision, get to know
     - the considerations to be taken into account
     - the major available alternatives and their strengths and limitations
3. Gain active experience in applying these ideas to a specific design problem

Abstract

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After defining the concept of a *user-adaptive system*, we will note the main usability issues that such systems raise and the reasons why they are gaining rapidly in importance. We will then consider, in turn, five high-level decisions that need to be made in the design of a system that adapts to its users:

1. What function is to be served by the adaptation?
2. What properties of users should be modeled?
3. What types of input data about the user should be processed?
4. How should the system make the necessary inferences about the user?
5. What empirical studies should be conducted to ensure or evaluate the success of the adaptation?

For each decision, we will discuss and evaluate, with reference to recent examples, the main alternatives that should be considered. During the interleaved workshop sessions, participants will make use of the ideas presented by working on the high-level design of a user-adaptive conference web site for CHI 2002.

Introduction

9 Example: Adaptive Route Advisor (1)

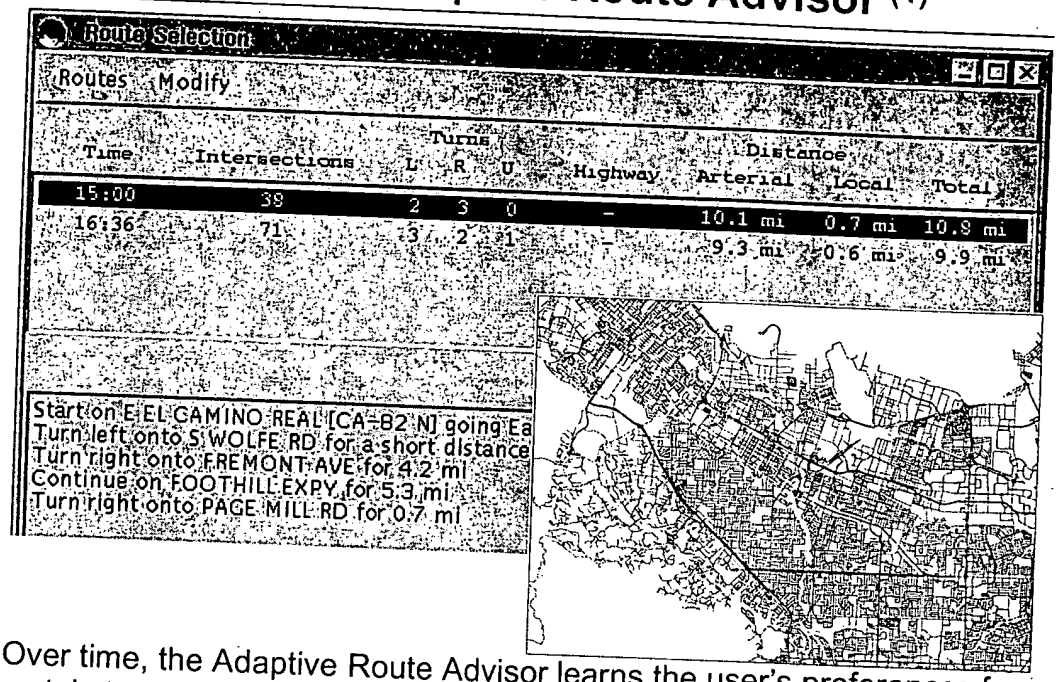

Figure 3 from Rogers, S., Fiechter, C., & Langley, P. (1999). An adaptive interactive agent for route advice. *Proceedings of the Third International Conference on Autonomous Agents*, Seattle, WA. http://riven.stanford.edu/~rogers/

Over time, the Adaptive Route Advisor learns the user's preferences for certain types of routes

Example: Adaptive Route Advisor (2)

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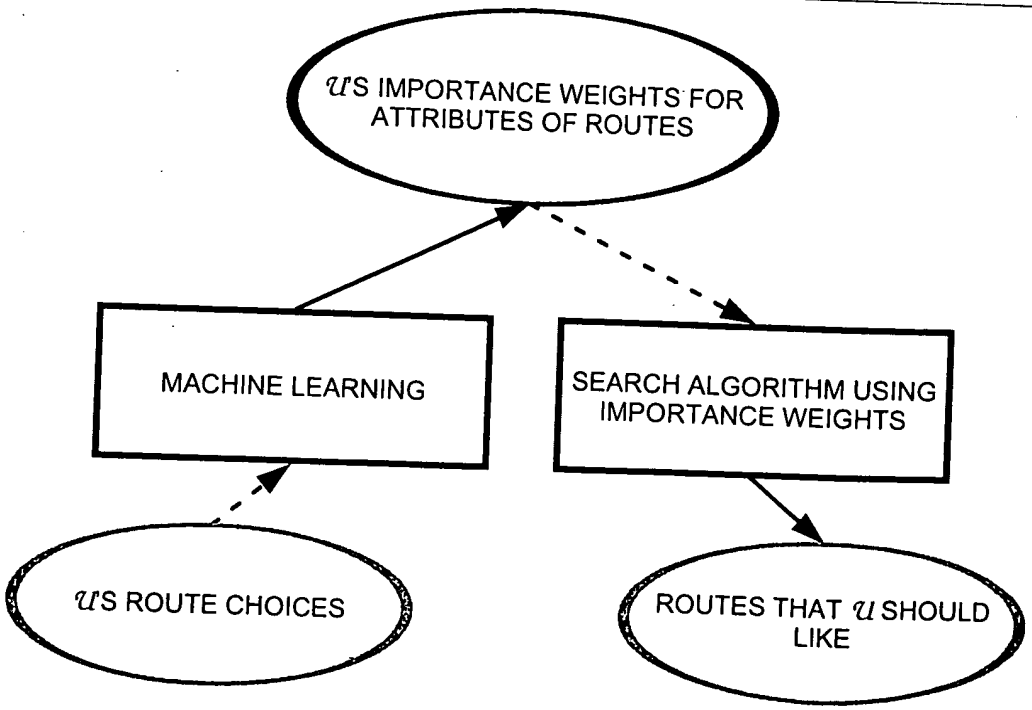

Adaptivity Within HCI

15 Where Are User-Adaptive Systems Found? (1)

In the HCI literature

- A small proportion of the systems studied in HCI are user-adaptive
  - About 2 full papers at each CHI conference*

In the literature of more specialized fields

- Adaptive / intelligent user interfaces
- Intelligent (information) agents
- User / student modeling

Where Are User-Adaptive Systems Found? (2) 16

Examples of systems in actual use

- Personalized web sites
  - Amazon: http://www.amazon.com
  - MyYahoo! http://www.yahoo.com
    (More adaptability than adaptation)
- Other commercially available systems
  - Office Assistant of Microsoft
    Best known, largely for features unrelated to adaptivity
  - Adaptive News Server of AdaptiveInfo (see http://www.adaptiveinfo.com)
    Young firm specializing in personalization for wireless devices
- Systems being used but not sold commercially
  (See discussions below:)
  - Publication Recommendation Agent
  - ELM-ART learning environment

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Central Usability Issue

Widespread concern

- Adaptation can reduce the *controllability* and *predictability* of a system for its users

Treatment of this problem here

- With different types of system, different degrees and forms of this problem
- Next subsection: Framework for analyzing it in specific cases

Shneiderman, B., & Maes, P. (1997). Direct manipulation vs. interface agents. *interactions*, 4(6), 42–61.

Three Levels of Controllability
Level 2: Skill

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Situation

- $\mathcal{U}$ is highly skilled in using a particular aspect $\mathcal{S}^*$ of a system
- *Automatic processing*, with little attention or conscious control
  (Typing, selecting frequently used menu items, ...)
- Reliance on $\mathcal{S}^*$ behaving consistently, predictably

Consequences of adaptation

- Automatic processing may be replaced by conscious, *controlled processing*
- Even if $\mathcal{U}$ is aware of the adaptation, processing may be disrupted and errors may be made

Recommendation

In general, avoid adaptation that could have these effects

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Level 1: Familiarity

Situation

- $\mathcal{U}$ is familiar with $\mathcal{S}^*$ (or with similar aspects of other systems)
- $\mathcal{U}$ has expectations about
  - where things can be found
  - what the effects of her actions will be
- $\mathcal{U}$ has some mental model of how $\mathcal{S}^*$ works

Consequences of adaptation

- $\mathcal{U}$ can to some extent cope with changes in $\mathcal{S}^*$'s behavior
- $\mathcal{U}$ may require more time and more trial and error to operate $\mathcal{S}^*$
- $\mathcal{U}$ may have more difficulty interpreting $\mathcal{S}^*$'s behavior

General recommendation

- Consider the seriousness of these costs of adaptation
- Try to reduce costs by
  - keeping adaptations moderate and infrequent
  - announcing them and obtaining $\mathcal{U}$'s approval
  - allowing them to be undone

Level 0: Lack of Knowledge and Control

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Situation

- $\mathcal{U}$ wants to get a particular type of result from $\mathcal{S}^*$
- $\mathcal{U}$ has at best vague expectations as to how $\mathcal{S}^*$ will behave or how $\mathcal{S}^*$ works
- $\mathcal{U}$ has little time or desire to understand $\mathcal{S}^*$ better
- $\mathcal{U}$ will just judge if the results produced are acceptable

Consequences of adaptation

- Adaptation may concern aspects of $\mathcal{S}^*$ that are not noticed by $\mathcal{U}$ anyway
- Adaptation may produce more useful results for $\mathcal{U}$

Recommendation

- Even drastic adaptation may be OK as long as these conditions hold
- Allow for a shift to adaptability if $\mathcal{U}$ might move to Level 1 or 2

Increasing Importance

21 Why Are These Systems Important Now? (1)

Decline in opportunities for controllability

- Users are finding it harder to achieve controllability on Levels 1 and 2 with all of the systems they use:
  - Systems are becoming more numerous

    Especially on the web, where each web site may be a new "system" – or a conglomerate of several new systems
  - Systems are becoming more complex

    With each new version, more functionality, more features ...
- So interaction on Level 0 is increasingly frequent and important
  - The benefits of adaptivity tend to be greatest here

Why Are These Systems Important Now? (2) 22

Increasing diversity of users and contexts of use*

- It is getting harder to design a system that is
  - highly usable for all types of users and contexts, or even
  - readily adaptable by users to their own properties and use contexts

Increasing feasibility of successful adaptation

- Broader bandwidth of communication from user to computer (in some types of system)
- Advances in machine learning and automated reasoning
- Greater technical support for flexibility in system behavior

*Cf. the CHI 2001 conference theme, "Anyone. Anywhere." See also Shneiderman, B. (2000). Universal usability. *Communications of the ACM, 43*(5), 84–91.

Functions (1)

23 Overview of Functions of Adaptation

1. Help $\mathcal{U}$ to Find Information
2. Tailor Information to $\mathcal{U}$
3. Recommend Products
4. Help With Routine Tasks
5. Adapt an Interface
6. Give Help
7. Support Learning
8. Conduct a Dialog
9. Support Collaboration

Questions About Functions of Adaptation (1) 24

Task

- What task is $\mathcal{U}$ and/or $\mathcal{S}$ performing?

Normal division of labor

- In a nonadaptive system, which aspects of the task would be performed by $\mathcal{U}$ and by $\mathcal{S}$?

Division of labor with adaptation

- How does adaptivity lead to a change in the division of labor – or in other aspects of the performance of the task?

Relevant properties of $\mathcal{U}$

- What are the main properties of $\mathcal{U}$ that $\mathcal{S}$ takes into account when deciding how to adapt?

25 Questions About Functions of Adaptation (2)

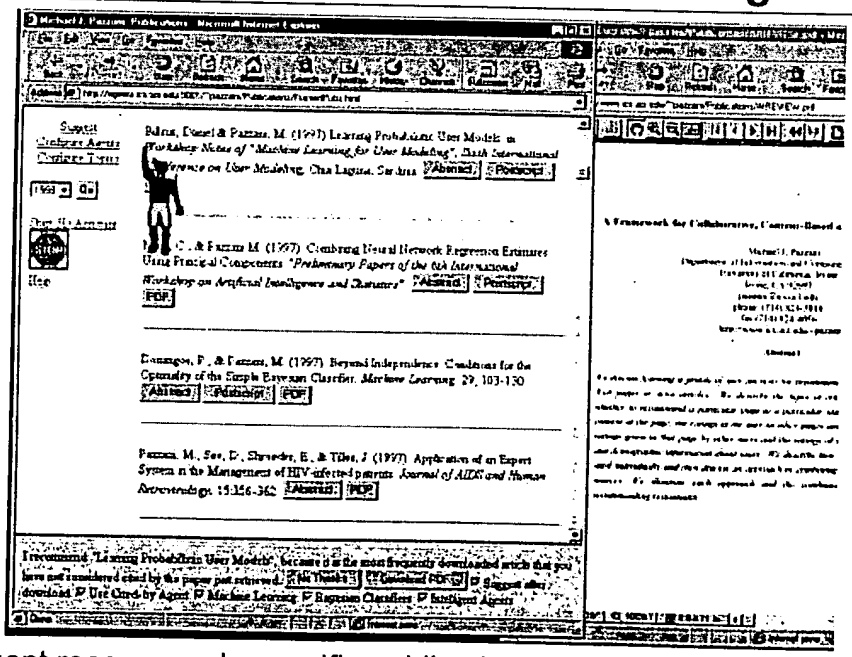
Potential benefits

- What are the main potential benefits of this type of adaptation?

Limitations

- What are the main difficulties or disadvantages?
- In particular, to what extent is controllability an issue?

Help U to Find Information
The Publication Recommendation Agent (1) 26



The agent recommends specific publications of Michael J. Pazzani to visitors to his web site

The agent is accessible via http://www.ics.uci.edu/~pazzani/Publications/Publications.html The animated agent is no longer available, but it is not required. Publication: Pazzani, M. J., & Billsus, D. (1999). Evaluating adaptive web site agents. *Proceedings of the Workshop on Recommender Systems Algorithms and Evaluation, 22nd International Conference on Research and Development in Information Retrieval.*

27 The Publication Recommendation Agent (2)

Recommendation principles

$\mathcal{S}$ has can suggest a publication $\mathcal{P}$ for several different reasons:

1. $\mathcal{P}$ is similar to the paper just downloaded
2. $\mathcal{P}$ cites the paper just downloaded
3. $\mathcal{P}$ is cited by the paper just downloaded
4. $\mathcal{P}$ is most frequently downloaded in combination with the last paper $\mathcal{U}$ downloaded
5. $\mathcal{P}$ has been added to the web page since $\mathcal{U}$'s last visit and $\mathcal{U}$ has previously downloaded a paper that is cited by $\mathcal{P}$
6. $\mathcal{P}$ is the most frequently downloaded paper that $\mathcal{U}$ hasn't considered

The Publication Recommendation Agent (3) 28

Adaptation

- $\mathcal{S}$ learns the relative *importance* of these reasons for $\mathcal{U}$ by learning from $\mathcal{U}$'s acceptance and rejection of recommendations

Adaptability

- $\mathcal{U}$ can also explicitly specify:
  - Which of the above reasons should *not* be considered
  - Which topic areas (in terms of key words) are of interest

Timing

- The agent makes a recommendation in three situations:
  1. $\mathcal{U}$ has clicked on the link "Suggest"
  2. $\mathcal{U}$ has just downloaded a paper
  3. The system has been idle for a few minutes

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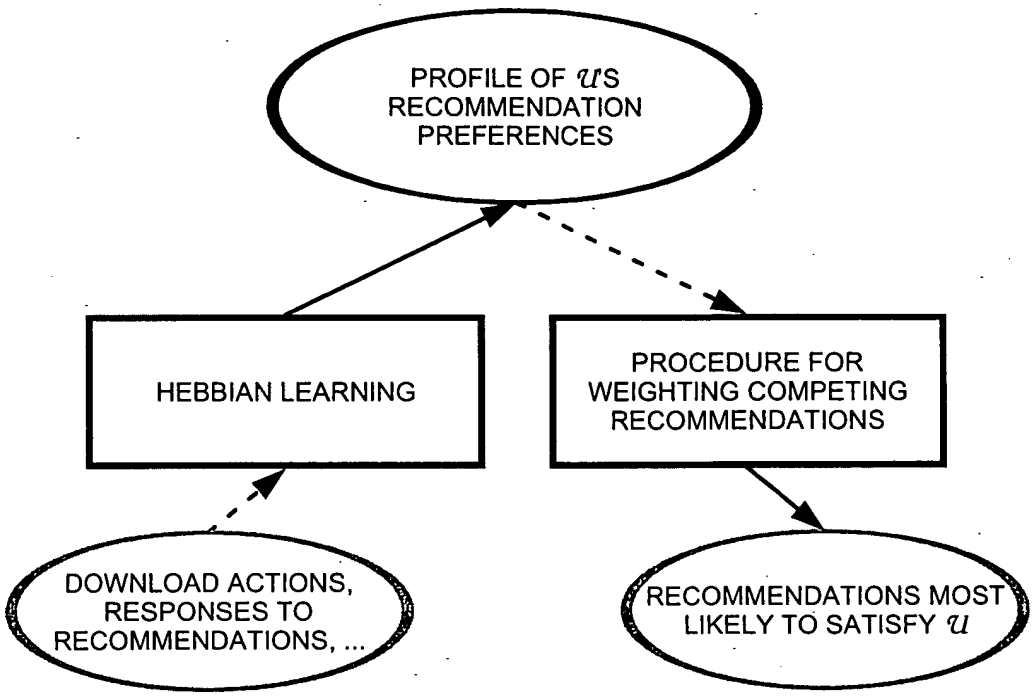
Overview of Adaptation



Evaluation

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Impact of agent on paper downloads

Period	Mean number of downloads per visit
60 days before introduction of agent	2.41
120 days after introduction of agent	4.77

Interpretation

Questions about the sharp increase:

1. Might it be due to:
   - the agent's aggressiveness in making recommendations?
   - users' enjoyment of interaction with the agent?
2. What can we infer about the specific appropriateness of $\mathcal{S}$'s recommendations for $\mathcal{U}$?

The authors controlled for factors such as proxies, spiders, and downloads that bypassed the agent (M. J. Pazzani, personal communication)

Discussion (1)

Task

- Finding information relevant to $\mathcal{U}$ in a large collection of information

Normal division of labor

- Browsing:
  - $\mathcal{U}$ navigates within a hypertext system
- Query-based information retrieval and filtering:
  - $\mathcal{S}$ retrieves items matching $\mathcal{U}$'s query
  - $\mathcal{U}$ looks for relevant items among those retrieved

Division of labor with adaptation

- Browsing:
  - $\mathcal{U}$ navigates, but $\mathcal{S}$ gives advice about where to look
- Query-based information retrieval and filtering:
  - $\mathcal{S}$'s choice and presentation of retrieved items take into account information about $\mathcal{U}$ that goes beyond $\mathcal{U}$'s query

Discussion (2)

Relevant properties of $\mathcal{U}$

- $\mathcal{U}$'s current information need, goals, and general interests

Potential benefits

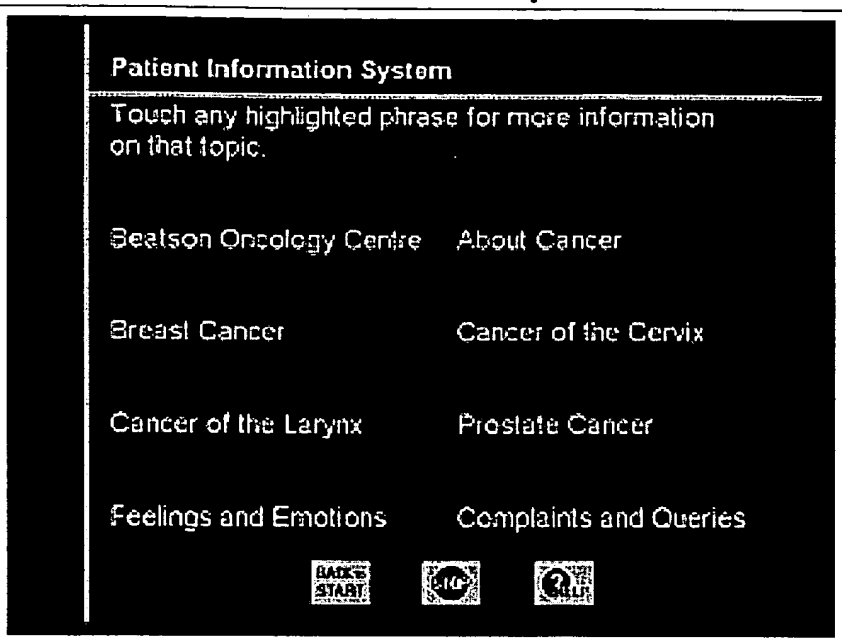
- Browsing:
  - Better decisions by $\mathcal{U}$ about what links to pursue
- Query-based information retrieval and filtering:
  - Higher recall and precision

Limitations

- For a skilled $\mathcal{U}$, it may be harder to interpret *absence* of results
  - "Are there really no results concerning *X*, or does $\mathcal{S}$ just think I'm not interested in them?"

Tailor Information to $\mathcal{U}$

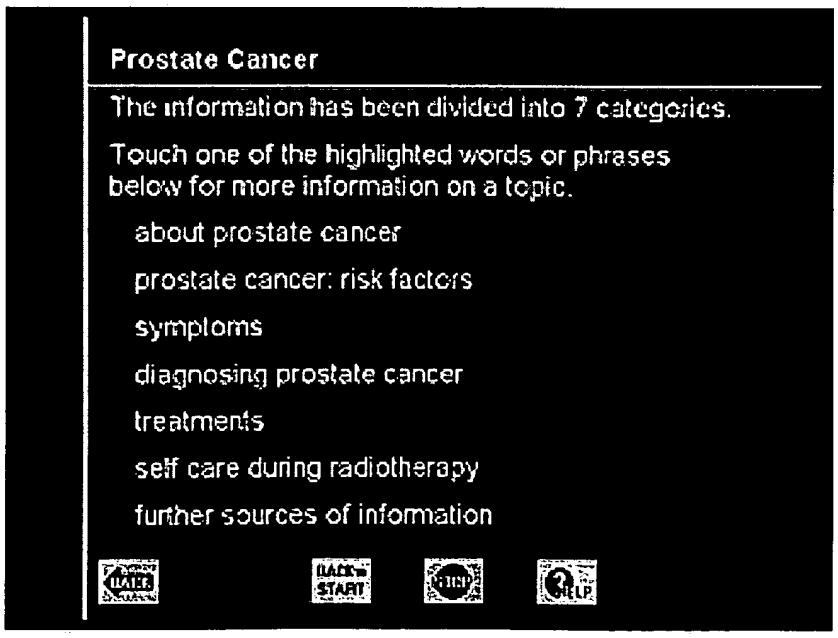
33 Medical Information: Nonpersonalized (1)



Nonpersonalized introductory screen
$\mathcal{U}$, who is being treated for prostate cancer, clicks on that topic

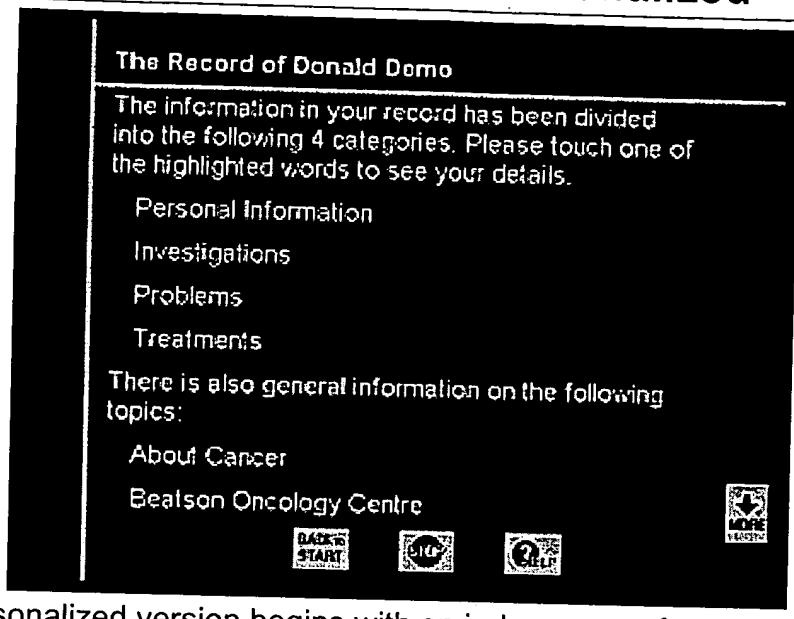
Jones, R., Pearson, J., McGregor, S., Cawsey, A. J., Barrett, A., Craig, N., Atkinson, J. M., Gilmour, W. H., & McEwen, J. (1999). Randomised trial of personalised computer based information for cancer patients. *British Medical Journal, 319*, 1241–1247. http://www.bmj.com/cgi/content/full/319/7219/1241

Medical Information: Nonpersonalized (2) 34



General overview screen on prostate cancer
By continuing to browse, $\mathcal{U}$ will access further nonpersonalized pages

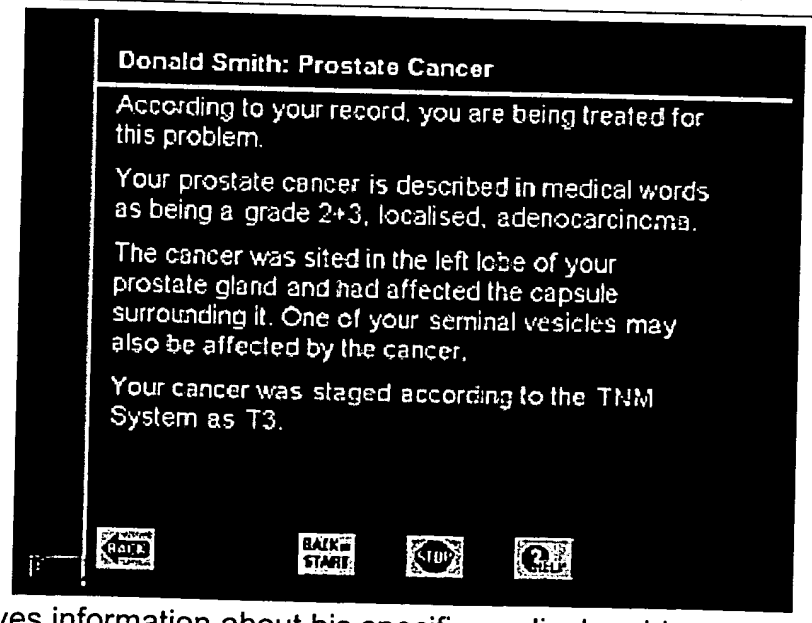
35 Medical Information: Personalized (1)



The personalized version begins with an index screen for the patient's medical record

$\mathcal{U}$ clicks on "Problems"

Medical Information: Personalized (2) 36



$\mathcal{U}$ receives information about his specific medical problem

By continuing to browse, $\mathcal{U}$ will access further personalized pages, as well as some nonpersonalized pages

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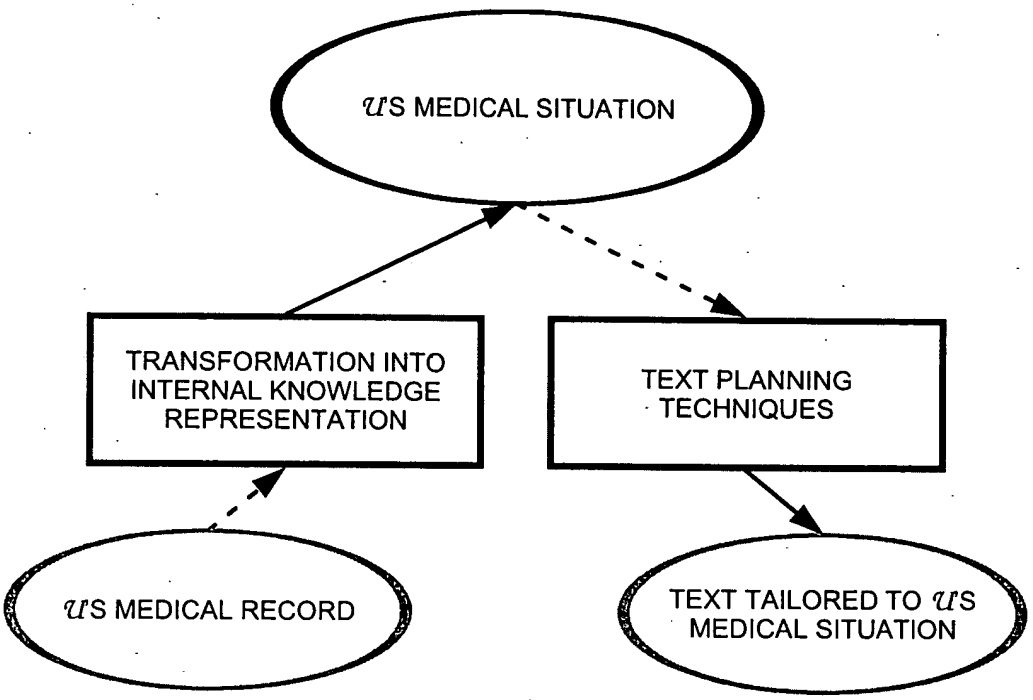
Overview of Adaptation



Evaluation (Summary)

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Main results of study of actual use

- Patients using personalized version ...
  - Found information much more relevant
  - Were somewhat more satisfied overall
  - Were a bit more inclined to use the system
- (Detailed results in Section "User Studies")

39 Discussion (1)

Task

- $\mathcal{S}$ presents information to $\mathcal{U}$ about some topic

Normal division of labor

- $\mathcal{S}$ (generates and) presents the same information in the same form to all users

Division of labor with adaptation

- $\mathcal{S}$ may generate a different presentation for each user, in terms of content and/or form

Relevant properties of $\mathcal{U}$

- Interests (sometimes inferred from personal characteristics)
- Knowledge
  - Influences $\mathcal{U}$'s need to see particular information and her ability to understand it
- Presentation preferences
  - For media, for concrete vs. abstract forms of presentation, ...

Discussion (2) 40

Potential benefits

- Greater comprehensibility, relevance, and enjoyment for $\mathcal{U}$

Potential controllability problems

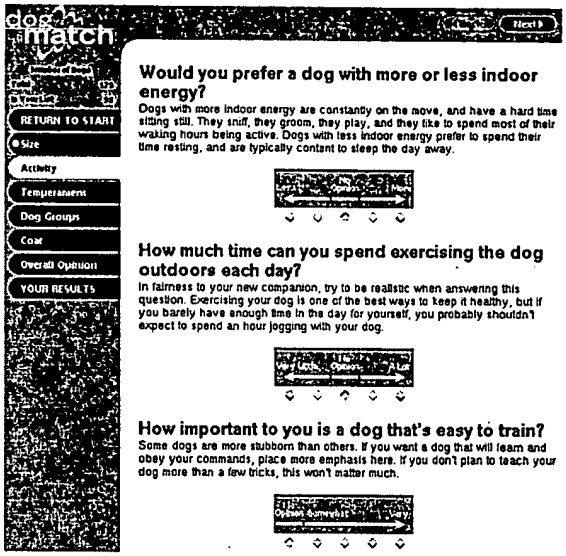
- Different users receive different information, so they can't communicate as easily with each other
- Changed presentations may be harder to interpret
- $\mathcal{U}$ may have less control over form and content

Avoiding controllability problems

- Don't change too often:
  - the form of presentation
  - the *general criteria* underlying the selection of content
- Announce such changes and have $\mathcal{U}$ approve them first
- Give $\mathcal{U}$ option of exercising control over presentation

Recommend Products

41 Explicit Approach: PersonaLogic



Sites like PersonaLogic recommend "products" after querying $\mathcal{U}$ explicitly about her evaluation criteria

The approach is also applied to items like pets, mutual funds, and presidential candidates

http://www.personalogic.com. "PersonaLogic" ™ is a trademark

MovieCentral (1)

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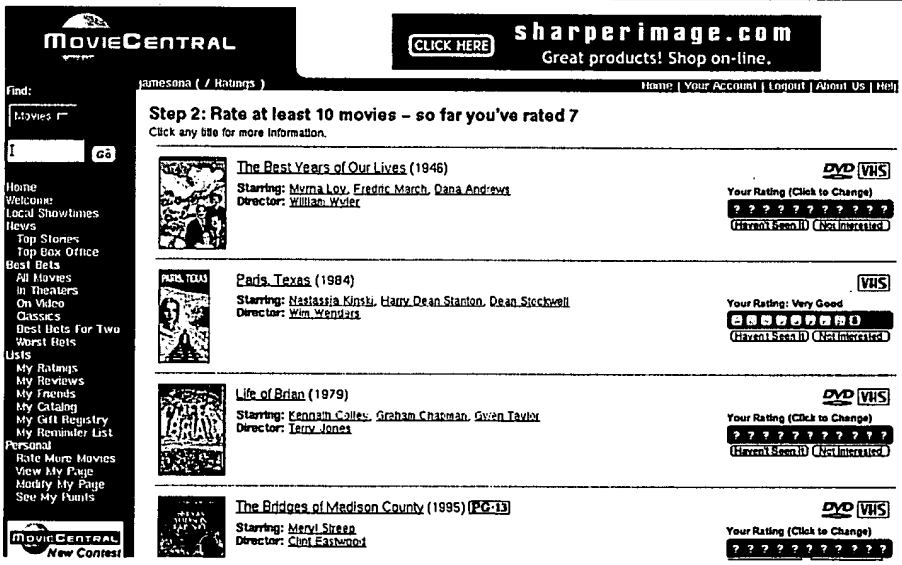

Sites like MovieCentral require no representation of $\mathcal{U}$'s evaluation criteria

After $\mathcal{U}$ has rated a certain number of films, $\mathcal{S}$ identifies other users with similar tastes

http://www.qrate.com/

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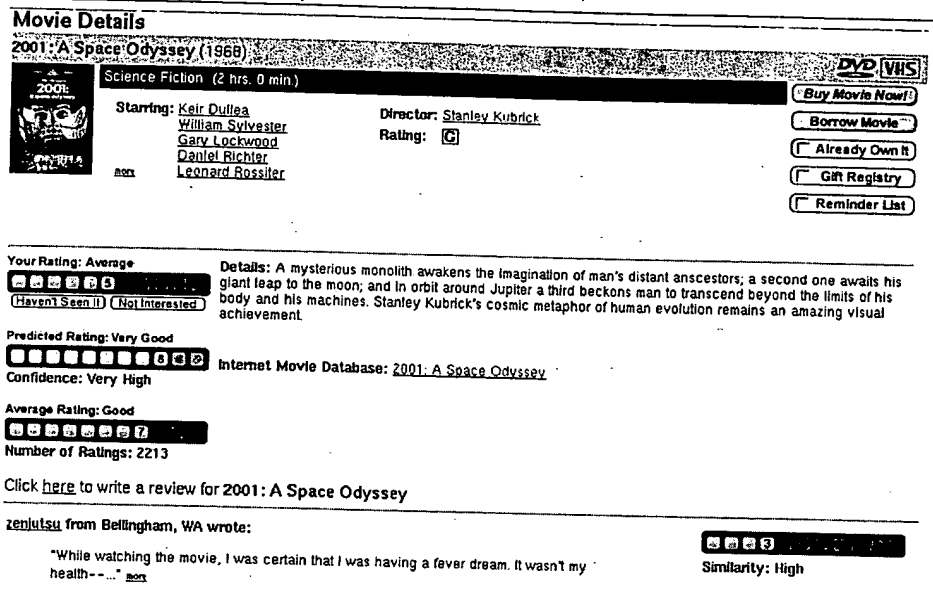
MovieCentral (2)



Having identified similar users, $\mathcal{S}$ can now

- predict how $\mathcal{U}$ will rate a given film
- present reviews from similar users

MovieCentral (3)

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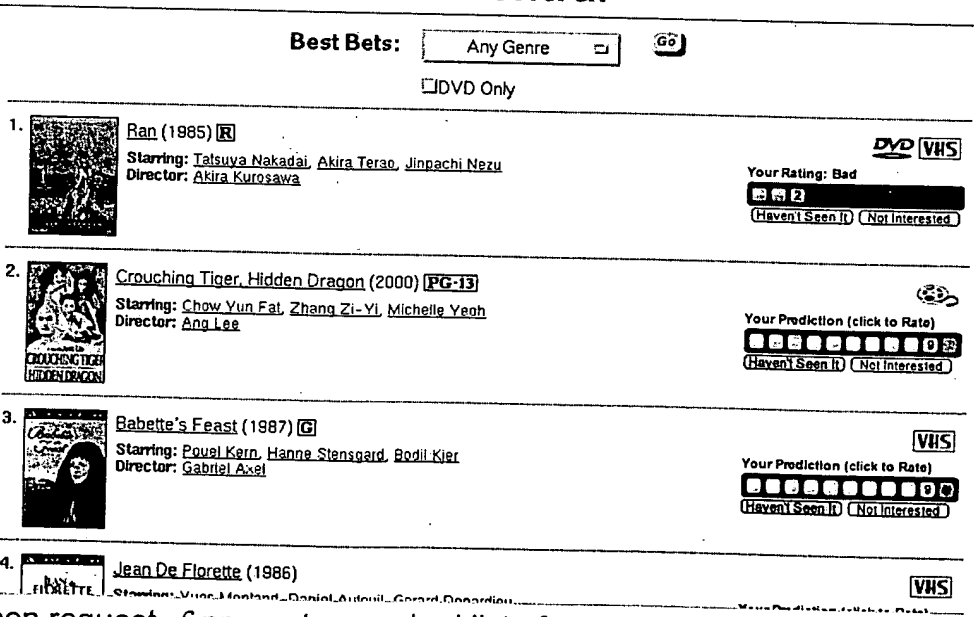

Upon request, $\mathcal{S}$ presents a ranked list of recommended films

The top recommendation had a predicted rating for $\mathcal{U}$ of 10

$\mathcal{U}$ now enters her actual rating of 3 ("bad")

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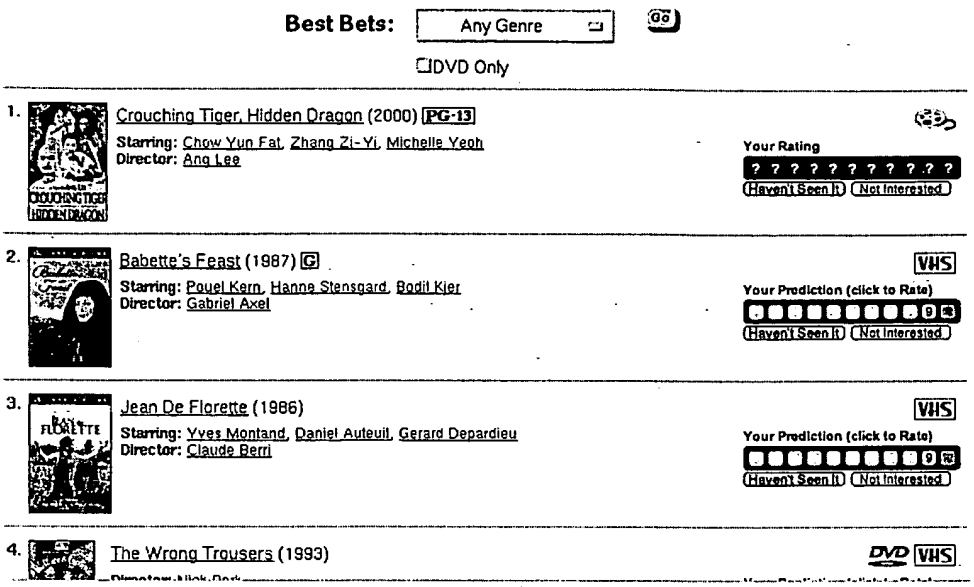
MovieCentral (4)



$\mathcal{U}$ has requested a new set of recommendations

The film rated "bad" has disappeared

Otherwise, no change is visible among the 11 recommendations

MovieCentral (5)

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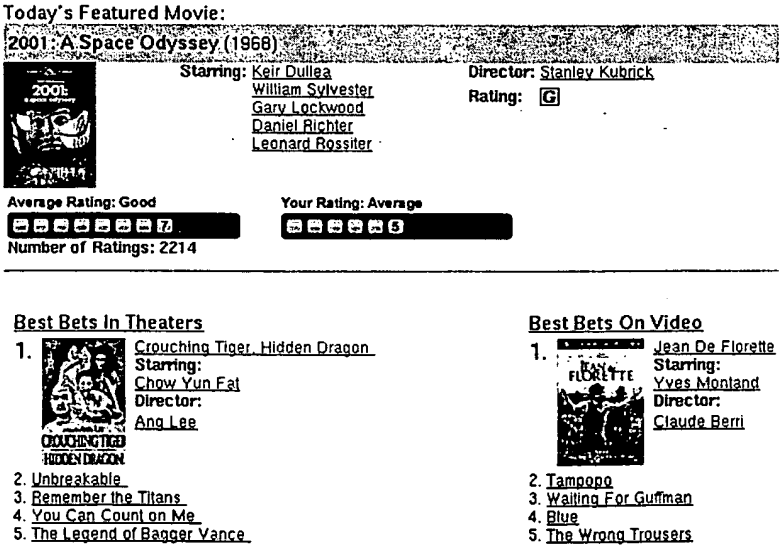

On January 1st, 2001, this film remained "Today's Featured Movie" even after $\mathcal{U}$ had given it an indifferent rating

More generally, product recommenders often leave some aspects of their pages insensitive to changes in the user profile

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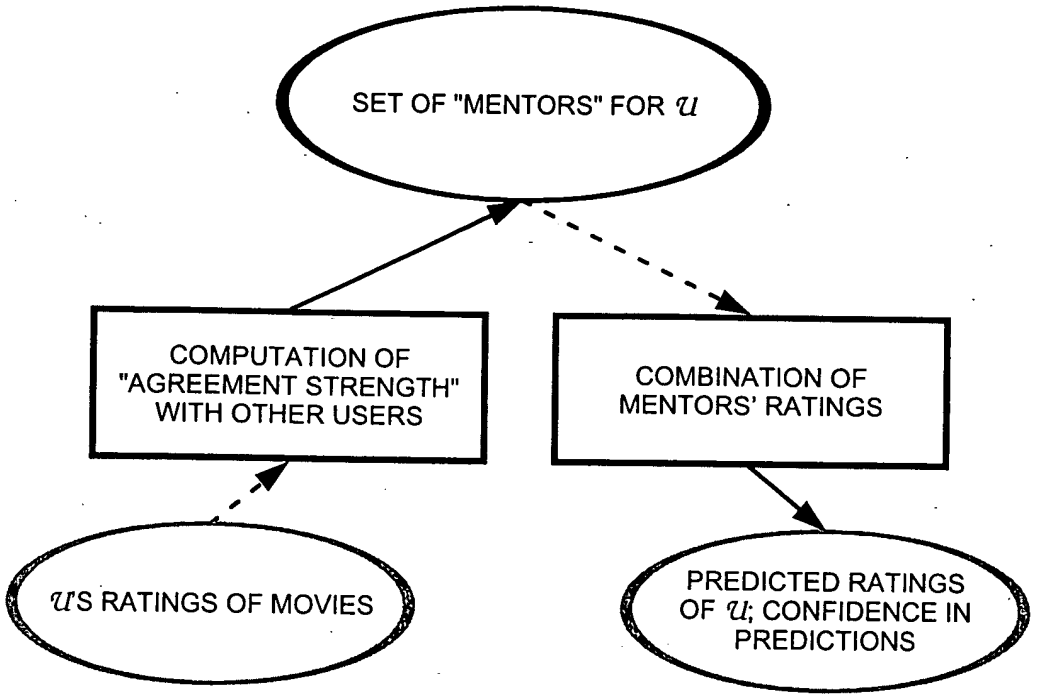
Overview of Adaptation



Further discussion in section "Inference"

Evaluation (1)

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Scientific research

- Many studies* have shown that social recommendation techniques such as those used at MovieCentral produce recommendations whose accuracy for an individual user is usefully high
  - See the discussion in the section on "Inference"

Use of commercial sites

- Regarding commercial sites, fewer scientific evaluations are available
- The claims on the following slide (paraphrased from a white paper on the LikeMinds personalization server) are typical

LikeMinds ® is a registered trademark
*See, e.g., Shardanand, U., & Maes, P. (1995). Social information filtering: Algorithms for automating "word of mouth". In I. R. Katz, R. Mack, L. Marks, M. B. Rosson, & J. Nielsen (Eds.), *Human factors in computing systems: CHI '95 conference proceedings* (pp. 210–217). New York: ACM.

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Evaluation (2)

Claims about effectiveness of LikeMinds

Behavior of typical user of a LikeMinds server:

- Rates 80 products
- Views 50 pages per visit
- Receives 40 product recommendations per visit

Survey responses of Movie Critic users:*

- Reasons for using Movie Critic
  - Saved them time and money choosing movies
  - Increased their confidence in selecting movies
  - Helped them see fewer duds
  - Was "just plain fun"
- Overall satisfaction
  - More than 90%: "love it" or "really good"

*Movie Critic is a demonstration system similar to MovieCentral: http://www.moviecritic.com/. See p. 2 and p. 14 of Greening, D. R. (2000). *Building consumer trust with accurate product recommendations: A white paper on Macromedia's LikeMinds personalization technology.* Boston: Macromedia. http://www.macromedia.com/

Discussion (1)

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Task

- Find objects suitable for use by $\mathcal{U}$

Normal division of labor

- $\mathcal{S}$ provides object descriptions
- $\mathcal{U}$ searches through them, evaluating the objects

Division of labor with adaptation

- $\mathcal{U}$ provides some indication of evaluation criteria
- $\mathcal{S}$ recommends suitable objects

Relevant properties of $\mathcal{U}$

- $\mathcal{U}$'s evaluation criteria

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Discussion (2)

Potential benefits

- $\mathcal{U}$ saves time and effort searching
- $\mathcal{U}$ covers a larger number of potential objects

Limitations

- $\mathcal{U}$'s evaluation criteria may be hard to assess adequately in the limited time available
- In commercial systems, issues of trust and responsibility are more complex when recommendations are made adaptively

Functions (2)

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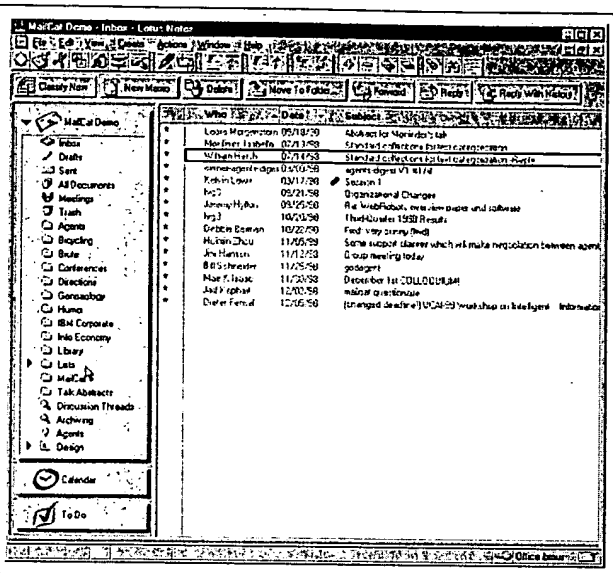
SwiftFile Demo (1)



Active users of electronic mail may receive dozens or even hundreds of messages every day

Message folders (left panel) allow users to organize their messages to ease later retrieval

SwiftFile Demo (2)

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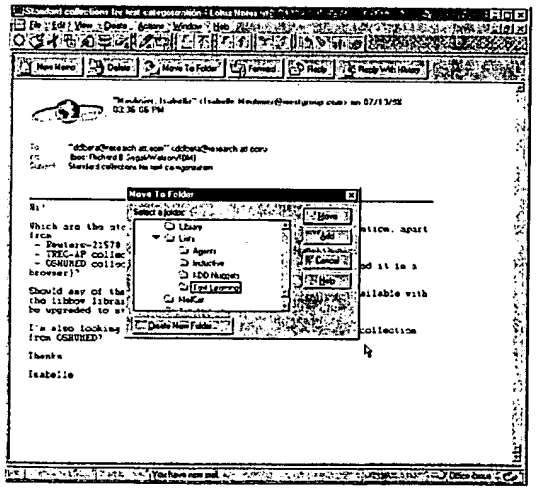

Messages are filed in Lotus Notes by pressing the MoveToFolder button and choosing the destination folder from a selection window

Regardless of the exact interface, the cognitive effort required to decide upon an appropriate folder and locate the icon or menu item representing it is substantial enough that many users fall behind in filing their e-mail

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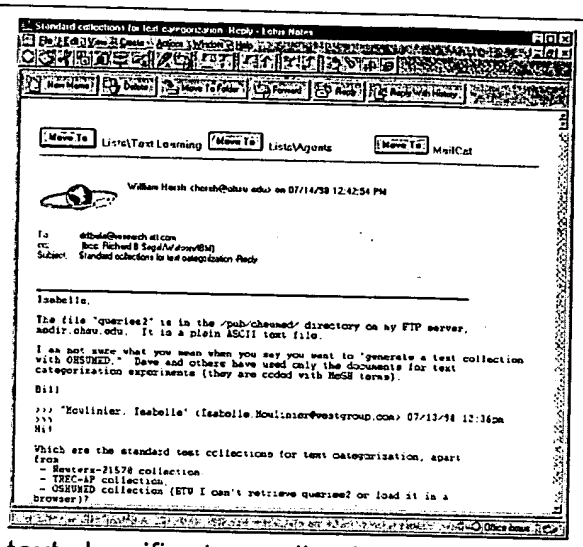
SwiftFile Demo (3)



SwiftFile uses a text classifier to predict the three most-likely folders for each message and provides shortcut buttons to quickly move each message into one of its predicted folders

When one of the three buttons is clicked, the message is immediately placed into the indicated folder

SwiftFile Demo (4)

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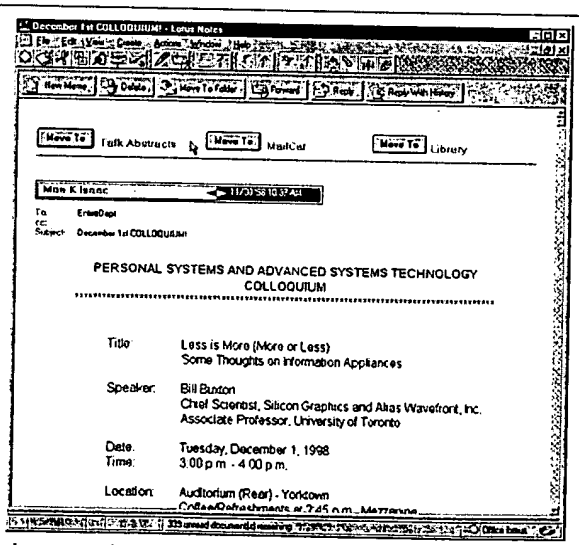

~ It has been found experimentally that SwiftFile provides the correct shortcut button between 80% and 90% of the time

In this screen shot, we see that SwiftFile can effectively predict broad topics such as "Talk Abstracts" even though the contents of this folder have messages on a variety of different subjects

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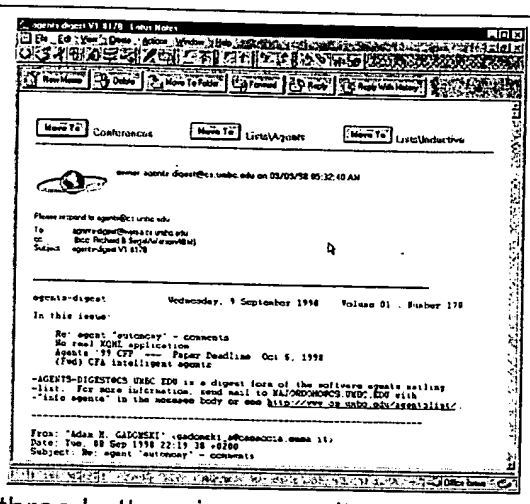
SwiftFile Demo (5)



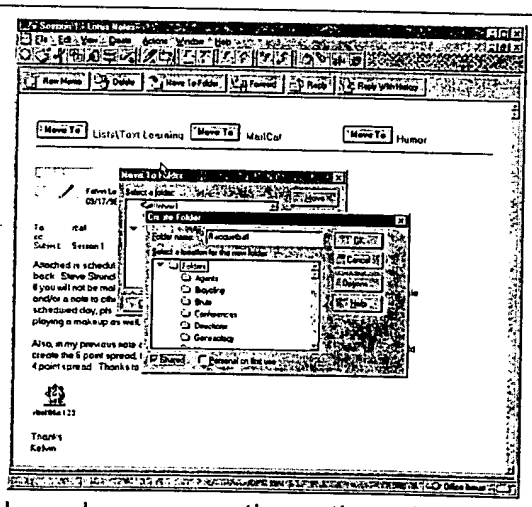
SwiftFile's use of three buttons improves its performance without placing any additional burdens on the user

This message from the Agents mailing list should be filed in "Lists\Agents" − SwiftFile's second choice

SwiftFile's first guess of "Conferences", although incorrect, is reasonable since the message contains conference announcements

SwiftFile Demo (6)

58



Since SwiftFile only makes suggestions, there is little cost to the user if SwiftFile fails to predict the correct folder

The user can just file the message using the application's normal interface

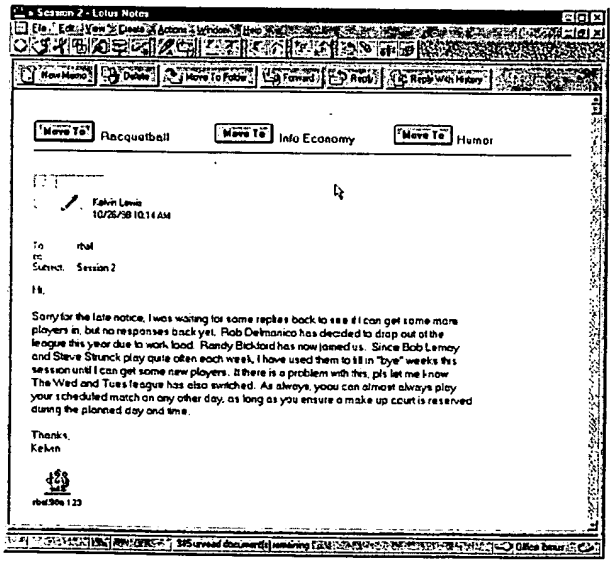
This message cannot be correctly predicted by SwiftFile because it is to be placed in a new folder

59 SwiftFile Demo (7)

When SwiftFile is first installed, SwiftFile uses the messages the user has currently stored in her folders to bootstrap its classifier

After its initial training, SwiftFile continually monitors changes to the user's mail database and uses incremental learning to keep its classifier up to date

SwiftFile Demo (8)

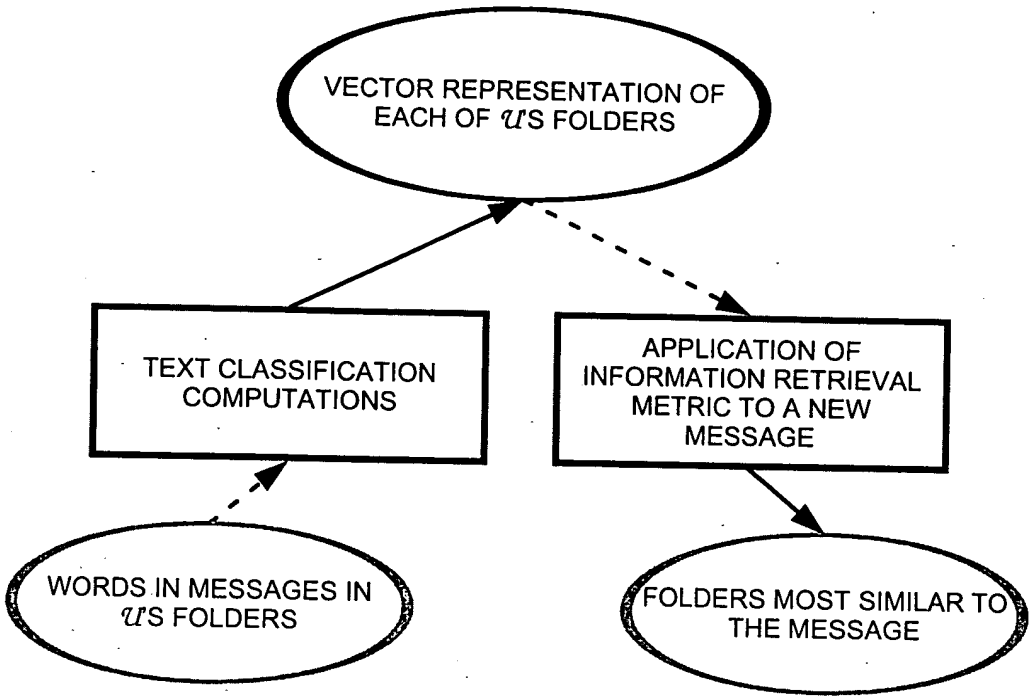


The user had to create a new folder when she received her first message about her racquetball league

SwiftFile immediately learns about the new folder and predicts that future messages about racquetball should go in the "Racquetball" folder

61

Overview of Adaptation



Evaluation

62

- As was indicated above, studies have shown that SwiftFile
  - provides the correct shortcut button between 80% and 90% of the time
  - is only slightly less accurate even with newly created folders
- One of these studies will be discussed in the section "User Studies"
- What questions concerning SwiftFile's value for users remain to be answered?

63 Discussion (1)

Task

- $\mathcal{U}$ performs some regularly recurring task that requires many specific decisions and/or operations
  - The task may involve devices other than traditional computers (e.g., cars, home heating systems)

Normal division of labor

- $\mathcal{U}$ makes the decisions and performs the operations individually

Division of labor with adaptation

- Strong form:
  - $\mathcal{S}$ makes the decisions and performs the operations on $\mathcal{U}$'s behalf
- Weak form:
  - $\mathcal{S}$ recommends specific decisions and offers to perform particular operations

Discussion (2) 64

Relevant properties of $\mathcal{U}$

- Preferences, interests, goals, etc.
- Note: Most systems in this category don't represent such properties explicitly; instead, they learn behavioral regularities of $\mathcal{U}$

Potential benefits

- $\mathcal{U}$ saves time and effort

Limitations

- Having $\mathcal{S}$ perform actions without consulting $\mathcal{U}$ can have serious negative consequences in individual cases
  - Unlike a human assistant, $\mathcal{S}$ may not be able to recognize exceptional cases that require $\mathcal{U}$'s attention
- When $\mathcal{S}$ does consult $\mathcal{U}$, the savings of time and effort for $\mathcal{U}$ may be limited

Adapt an Interface

65 Smart Menus: Introduction

These principles were inferred by the presenter through experience with Smart Menus; the actual principles may be more complex

History

- Introduced in Microsoft Windows 2000 (including Office 2000) and later in Windows ME
- Simple instance of a long tradition of *adaptive menus*

Basic idea

- Each menu initially includes only basic items
- When $\mathcal{U}$ clicks at bottom:
  - More items appear within menu
  - Overall order stays the same
- When $\mathcal{U}$ selects a previously unused item:
  - Item is thereafter included in the initial menu

Smart Menus: Example 66

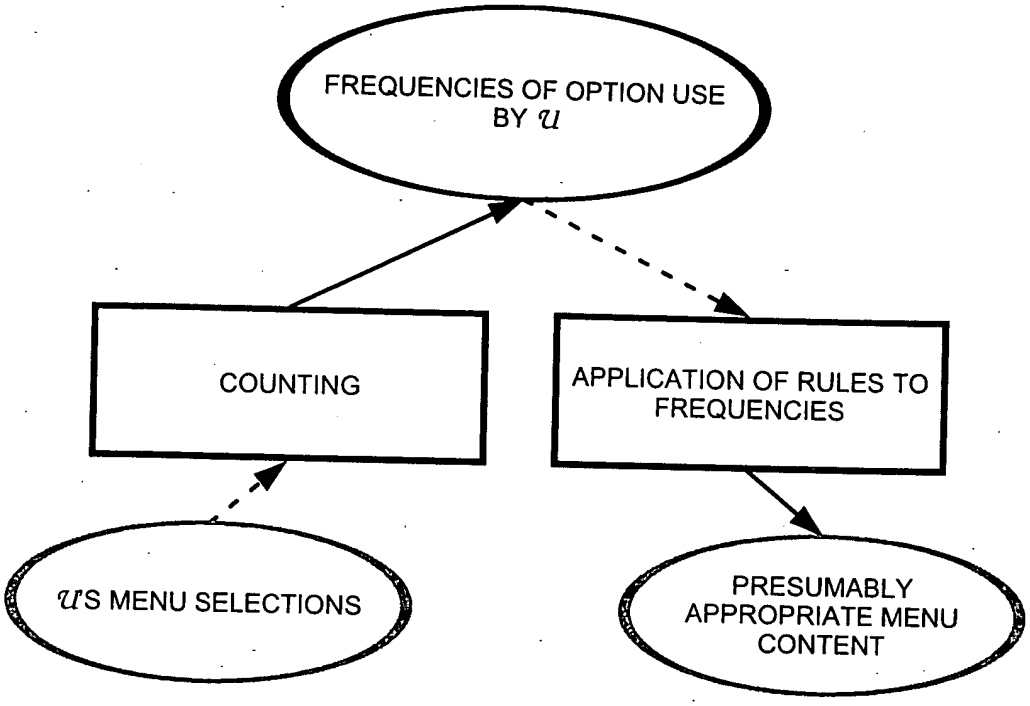
1. $\mathcal{U}$ accesses "Insert" menu

2. Not finding desired option, $\mathcal{U}$ clicks on extension arrows and selects "Feld" option

3. $\mathcal{U}$ later accesses same menu

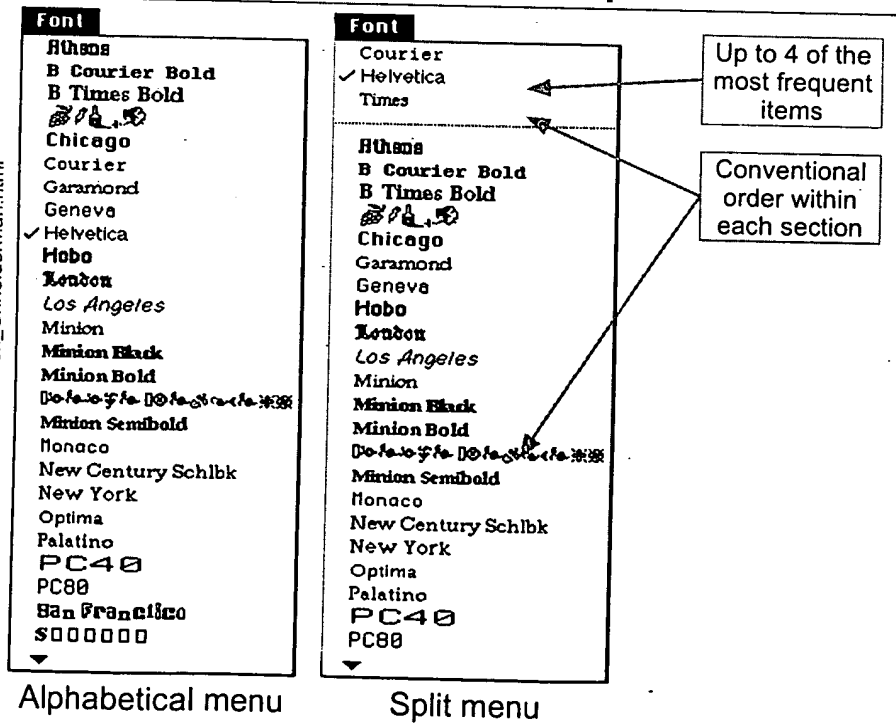
67

Overview of Adaptation



A Similar Idea: Split Menus

68



Sears, A., & Shneiderman, B. (1994). Split menus: Effectively using selection frequency to organize menus. *ACM Transactions on Computer-Human Interaction, 1*, 27–51. http://www.cs.umd.edu/TRs/authors/Ben_Shneiderman.html

69 Relevant Previous Evaluations (1)

Advantages of "split menus"

Basic idea

- Like Smart Menus, split menus make the most frequently accessed items more easily available (see next slide)

Studies by Sears and Shneiderman (1994)

- Comparison
  - Constant split menus vs. constant menus of other formats (i.e., no adaptation during use)
- Advantages for split menus in field study:
  - Significant subjective preference
  - 17–58% faster mean selection times
- Advantages for split menus in experiment:
  - Subjective preference over alphabetic and frequency-ordered menus
  - Always at least as fast as alphabetic menus

Relevant Previous Evaluations (2) 70

Drawbacks of automatic menu adaptation

Comparison by Mitchell and Shneiderman (1989)

- Static menus vs. menus automatically reorganized on basis of $\mathcal{U}$s current pattern of selections

Drawbacks of automatically adapted menus

- Lower subjective ratings at first exposure and after practice
- Lower speed and more errors during initial use
- (No performance difference after practice)

How to achieve benefits of menu adaptation with minimal disruption?

1. How often and under what circumstances should menus be changed?
2. Should each change be announced to $\mathcal{U}$ (and perhaps approved by $\mathcal{U}$)?
3. Should an undo mechanism for adaptations be included?

Mitchell, J., & Shneiderman, B. (1989). Dynamic versus static menus: An exploratory comparison. *SIGCHI Bulletin, 20*(4), 33–37.

71 Discussion (1)

Task

- $\mathcal{U}$ works with one or more applications through a given interface

Normal division of labor

- $\mathcal{U}$ learns to deal with the given interface, perhaps adapting it explicitly

Division of labor with adaptation

- $\mathcal{S}$ modifies the interface to make it more suitable for $\mathcal{U}$, perhaps after consulting $\mathcal{U}$ for approval
- Types of modification:
  - How should input methods be adjusted?
    Keyboard properties, ...
  - What functions should be made available or highlighted?
  - How should aspects of the display be adjusted?
    Colors, fonts, ...

Discussion (2) 72

Relevant properties of $\mathcal{U}$

- Noncognitive skills (e.g., motor or visual disabilities)
- Tendency or ability to use particular functions

Potential benefits

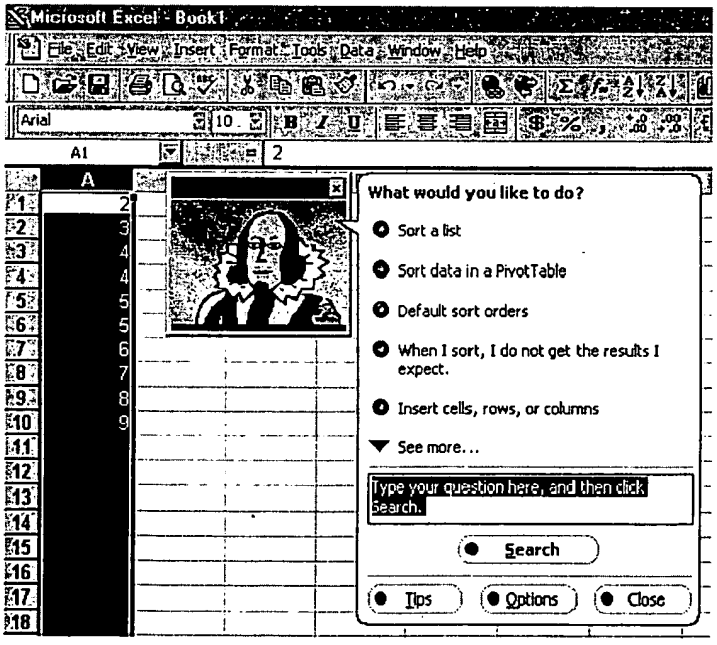
- Saving of time, effort, errors, and frustration in using the interface
- Avoidance of need to specify interface adaptations explicitly
  - $\mathcal{U}$ may not know what an appropriate specification would be
    Example: Optimal delay before a key starts repeating
  - Specifications might have to be made in each individual case, as opposed to just once and for all
    E.g., suitable choice of fonts and colors for each individual graph

Discussion (3)

Limitations

- Since some interface elements are used with high frequency, $\mathcal{U}$ is especially likely to become skilled in using them ("Level 2")
- Consistency and predictability and therefore especially critical issues with this type of adaptation

Give Help
Lumière Prototype

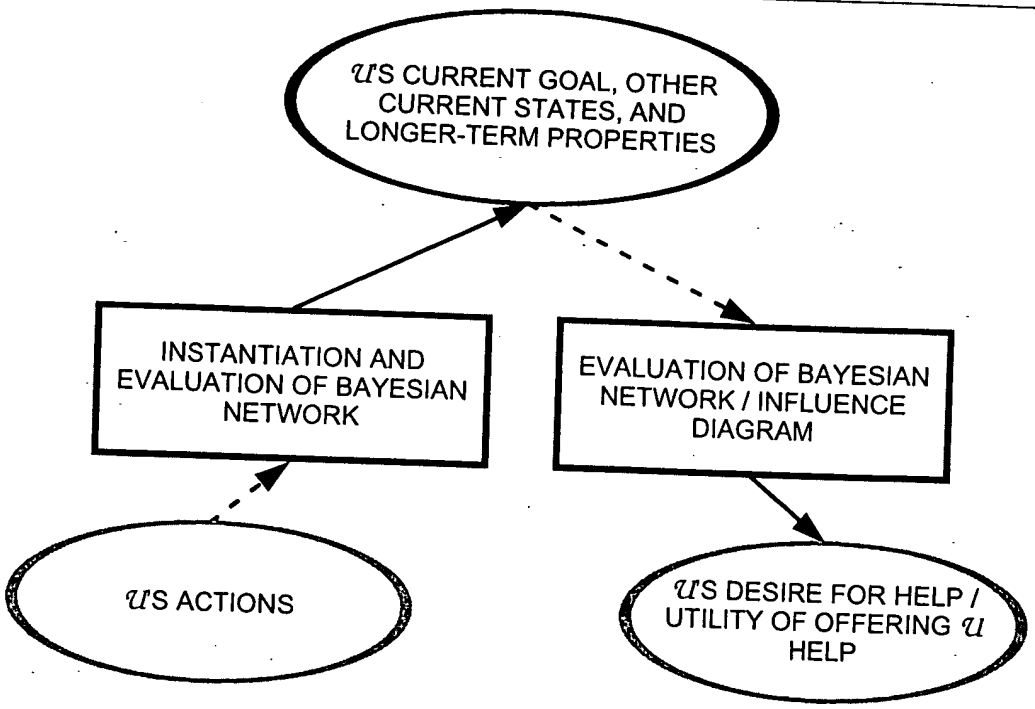


Lumière, developed at Microsoft Research, was the initial prototype of the Office Assistant

http://research.microsoft.com/~horvitz/lum.htm Cf. Horvitz, E., Breese, J., Heckerman, D., Hovel, D., & Rommelse, K. (1998). The Lumière project: Bayesian user modeling for inferring the goals and needs of software users. In G. F. Cooper & S. Moral (Eds.), *Uncertainty in Artificial Intelligence: Proceedings of the Fourteenth Conference* (pp. 256–265). San Francisco: Morgan Kaufmann. http://www2.sis.pitt.edu/~dsl/UAI/uai.html

75

Overview of Adaptation



Relevant Experience

76

- The basic features of Lumière are hard to recognize in the Office Assistant because of the inclusion of other mechanisms:
  - Lifelike behaviors unrelated to the adaptive features
  - Tips derived through less sophisticated mechanisms than those of the Lumière prototype
  - Standard dialog boxes that are presented by the same character that provides adaptive assistance
- An empirical study conducted early in the development of Lumière is summarized in the section "User Studies"
- Schaumburg (2001) has investigated users' assessments of the Office Assistant

Schaumburg, H. (2001). Computers as tools or as social actors? - the users' perspective on anthropomorphic agents. *International Journal on Intelligent Cooperative Information Systems.* http://www.cmr.fu-berlin.de/faculty/heike/publications.html

Discussion (1)

Task

- $\mathcal{U}$ finds out how to use an application successfully and efficiently

Normal division of labor

- $\mathcal{U}$ searches through documentation and engages in trial and error

Division of labor with adaptation

- $\mathcal{U}$ does basically the same things, but $\mathcal{S}$ gives hints to expedite the process

Relevant properties of $\mathcal{U}$

- Knowledge of the application
- Current goal
- Desire to be helped by $\mathcal{S}$

Discussion (2)

Potential benefits

- $\mathcal{U}$ finds relevant functions and documentation more quickly and with less frustration
- $\mathcal{U}$ discovers aspects of the application that $\mathcal{U}$ would otherwise never have known about

Limitations

- Reasonably accurate assessment by $\mathcal{S}$ can be very difficult
  - The relevant properties are usually reflected only indirectly in $\mathcal{U}$s behavior
  - $\mathcal{U}$'s current goal can change quickly
- Interventions by $\mathcal{S}$ that aren't helpful can be distracting and misleading

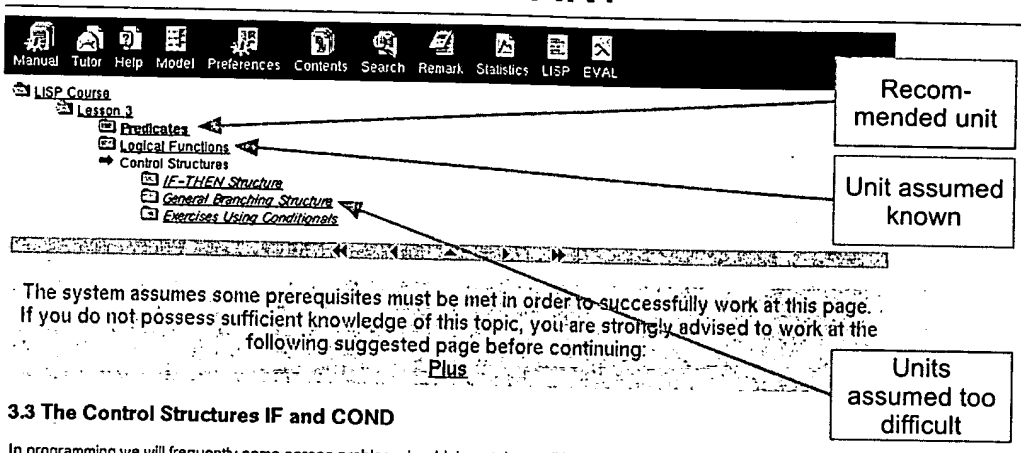
Avoiding controllability problems

- Make it easy for $\mathcal{U}$ to ignore $\mathcal{S}$s spontaneous advice (without turning $\mathcal{S}$ off entirely)

Support Learning

79

ELM-ART



ELM-ART is a web-based tutor for the programming language LISP

Its link annotations indicate how accessible each part of the course currently is for $\mathcal{U}$

It also recommends a particular page to be visited next

ELM-ART: Pedagogical Navigation Support

80

Goals

1. Allow $\mathcal{U}$ considerable freedom in exploring the site
2. Help $\mathcal{U}$ to avoid visiting
   - pages whose content $\mathcal{U}$ presumably already knows
     Perhaps on the basis of previous learning elsewhere
   - pages that $\mathcal{U}$ could not yet understand
     Because $\mathcal{U}$ lacks prerequisite knowledge

Form of hints

- Link annotations ("traffic lights") indicate the extent to which a visit to a unit is recommended
- A "Next Button" recommends a single unit to be visited next

Underlying principles

- $\mathcal{S}$ includes a model of the prerequisite relationships among units
- When a unit has been marked as "known", $\mathcal{S}$ may infer that other units are known

ELM-ART also contains other user-adaptive elements, for example, concerning the selection of examples

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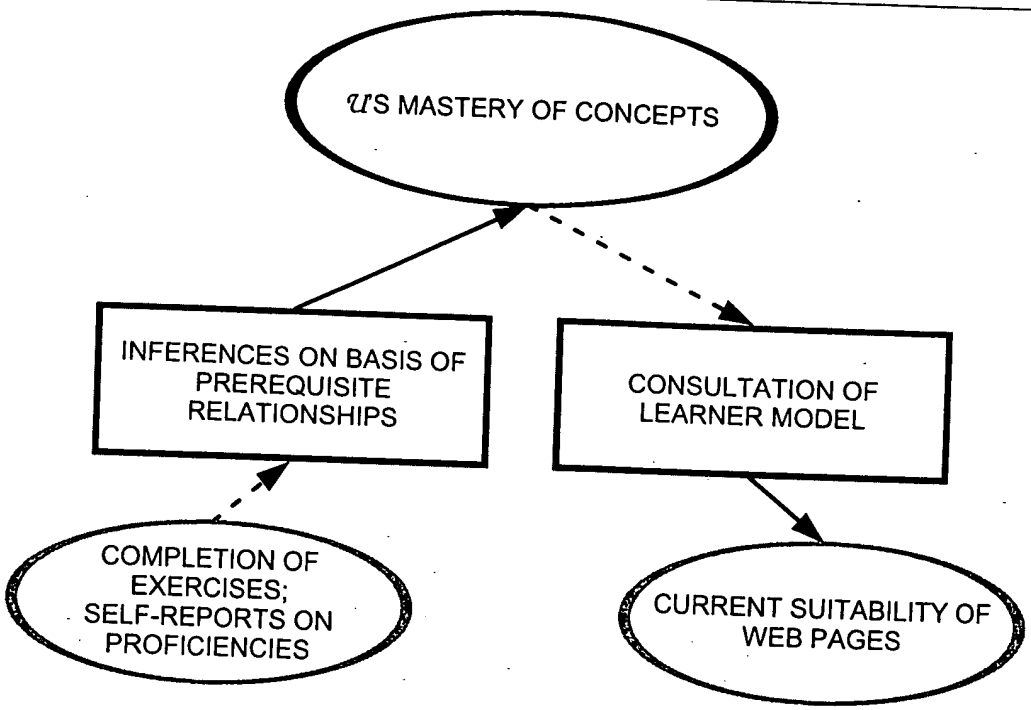
Overview of Adaptation



Evaluation of Navigation Support

82

Method

- Subjects: 33 users, 16 of whom were given access to a "Next" button

Results

- Users with access to the "Next" button:
  1. Visited 80% more pages in all; $p < .05$
     - Result found *only* for the 14 learners without previous programming knowledge (mostly web novices, unfamiliar with browsers)
  2. Required 28% fewer navigation steps for Lesson 1; difference not significant in small sample
     - No difference for later lessons

Discussion

- The "Next" button had noticeable added value only when the navigation challenges were especially unfamiliar to users
- More subtle effects might be found in a larger sample

Summarized on the basis of Weber, G., & Specht, M. (1997). User modeling and adaptive navigation support in WWW-based tutoring systems. In A. Jameson, C. Paris, & C. Tasso (Eds.), *User modeling: Proceedings of the Sixth International Conference, UM97* (pp. 289–300).Vienna: Springer Wien New York. http://www.cs.uni-sb.de/UM97/

Discussion (1)

Task

- $\mathcal{S}$ acquires knowledge and/or skills in some topic area

Normal division of labor

- $\mathcal{S}$ provides information, exercises, tests, hints, and feedback
- $\mathcal{U}$ processes this material and learns

Division of labor with adaptation

- $\mathcal{S}$ performs basically the same subtasks but more strongly dependent on properties of the individual $\mathcal{U}$

Relevant properties of $\mathcal{U}$

- Prior knowledge and knowledge acquired during interaction
- Learning style, motivation, viewpoints, ...
- Current specific goals and beliefs (e.g., misconceptions)

Potential benefits

- Faster, better, and/or more enjoyable learning by $\mathcal{U}$

Discussion (2)

Limitations

- Decision-relevant inferences about the specific $\mathcal{U}$ may be difficult to make accurately
- Decisions by $\mathcal{S}$ may not need to depend on such inferences
  - Example: $\mathcal{S}$ can teach a correct method without knowing what incorrect method $\mathcal{U}$ is currently employing

Avoiding controllability problems

- Ensure that the *general principles* underlying $\mathcal{S}$'s adaptive decisions can be comprehended by $\mathcal{U}$
- Allow $\mathcal{U}$ to inspect the learner model

Conduct a Dialog

85 Example Dialog With TOOT (1)

Litman, D. J., & Pan, S. (2000). Predicting and adapting to poor speech recognition in a spoken dialogue system. *Proceedings of the Seventeenth National Conference on Artificial Intelligence*, Austin, TX, pp. 722–728. http://www.research.att.com/~diane/dslearning-pubs.html

The prototype spoken dialog system TOOT automatically adapts its style of conversing with $\mathcal{U}$ when it detects problems in the dialog

Beginning with ambitious dialog strategy

$\mathcal{S}$:	Hi, this is AT&T Amtrak Schedule System. This is TOOT. How may I help you?	
$\mathcal{U}$:	I need to find a train going to New York City. *(ASR: DC I don't care on Thursday.)*	−5.29
$\mathcal{S}$:	Which city do you want to leave from?	
$\mathcal{U}$:	Baltimore.	−1.73
$\mathcal{S}$:	Do you want me to find the trains from Baltimore to DC on Thursday at anytime now?	
$\mathcal{U}$:	No.	−2.09
$\mathcal{S}$:	How may I help you?	
$\mathcal{U}$:	I need to leave on Sunday. *(ASR: DC between 1 night and 8.)*	−4.91

Note: Rightmost column: $\mathcal{S}$'s confidence in its own speech recognition

Example Dialog With TOOT (2) 86

After switch to more conservative dialogue strategy

$\mathcal{S}$:	I heard you say go to DC between 1 night and 8. Do you want me to find the trains from Baltimore to DC on Thursday between 1 night and 8 now?	
$\mathcal{U}$:	No. *(ASR: Help.)*	−2.80
$\mathcal{S}$:	You can say yes or no.	
$\mathcal{U}$:	No.	−2.50
$\mathcal{S}$:	How may I help you?	
$\mathcal{U}$:	I need to go to New York City from Baltimore on Sunday at 8:30 pm. *(ASR: To Chicago Tuesday 8:45 am.)*	−5.94
$\mathcal{S}$:	I heard you say go to Chicago on Tuesday around 8:45 am. Do you want me to find the trains from Baltimore to Chicago on Tuesday around 8:45 am now?	
$\mathcal{U}$:	No.	−3.35

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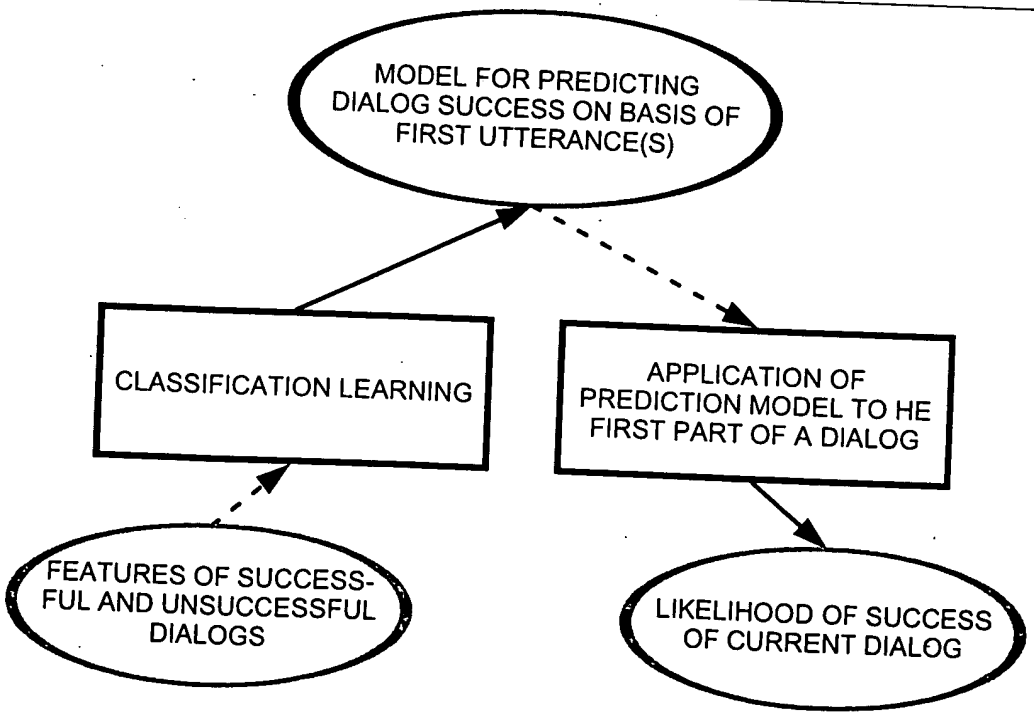
Example Dialog With TOOT (3)

After switch to even more conservative strategy

S:	Which city do you want to go to?	
U:	New York City.	
S:	Do you want to go to New York City?	−1.67
U:	Yes.	
S:	Which city do you want to leave from?	−0.77
U:	Baltimore.	
S:	Do you want to leave from Baltimore?	−1.44
U:	Yes.	
(... Same procedure for day and time ...)		−0.60
S:	Do you want me to find the trains from Baltimore to New York City on Sunday around 8:30 pm now?	
U:	Yes.	
S:	I am going to get the train schedules for you . . .	−0.58

Overview of Adaptation

88



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Evaluation (Summary)

- Nonadaptive and adaptive variants of TOOT were compared in an experimental setting
- Advantages of adaptive version:
  1. Much higher rate of successful dialog completion (63% vs. 23%)
  2. Marginally greater subjective satisfaction
- Adaptive TOOT adapted to different extents in different dialogs
- (Further details in section "User Studies")

Discussion (1)

90

Task

- Achieve $\mathcal{U}$'s goals through a natural language dialog between $\mathcal{U}$ and $\mathcal{S}$

Normal division of labor

- $\mathcal{U}$ figures out what to say in order to obtain the desired results from $\mathcal{S}$

Division of labor with adaptation

- $\mathcal{U}$ expresses herself more or less spontaneously
- $\mathcal{S}$ adapts content of utterances and/or dialog style to $\mathcal{U}$'s requirements

Relevant properties of $\mathcal{U}$

- $\mathcal{U}$'s current information need, goals, and general interests
- Aspects of $\mathcal{U}$'s dialog behavior and/or speech

The complex issue of when natural language is an appropriate communication modality between human and computer exceeds the scope of this tutorial; the discussion here refers to cases where natural language is appropriate.

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Discussion (2)

Potential benefits

- Dialogs proceed more swiftly and/or more successfully

Limitations

- If $\mathcal{U}$ tries to understand the principles underlying $\mathcal{S}$'s dialog behavior, adaptation by $\mathcal{S}$ can make this task more difficult

Support Collaboration
PHelpS: Getting Peer Help

92

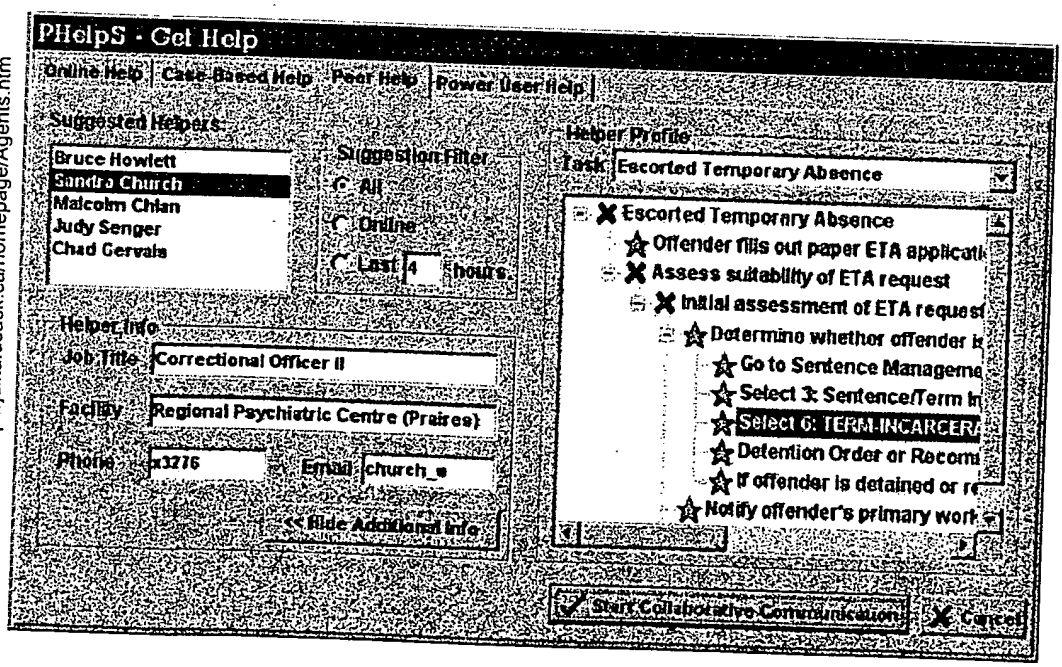


Figure 2 of Greer, J. E., McCalla, G. I., Collins, J. A., Kumar, V. S., Meagher, P., & Vassileva, J. (1998). Supporting peer help and collaboration in distributed workplace environments. *International Journal of AI and Education, 9*, 159–177. http://julita.usask.ca/homepage/Agents.htm

93

PHelpS: Context of Use

Subjects and setting

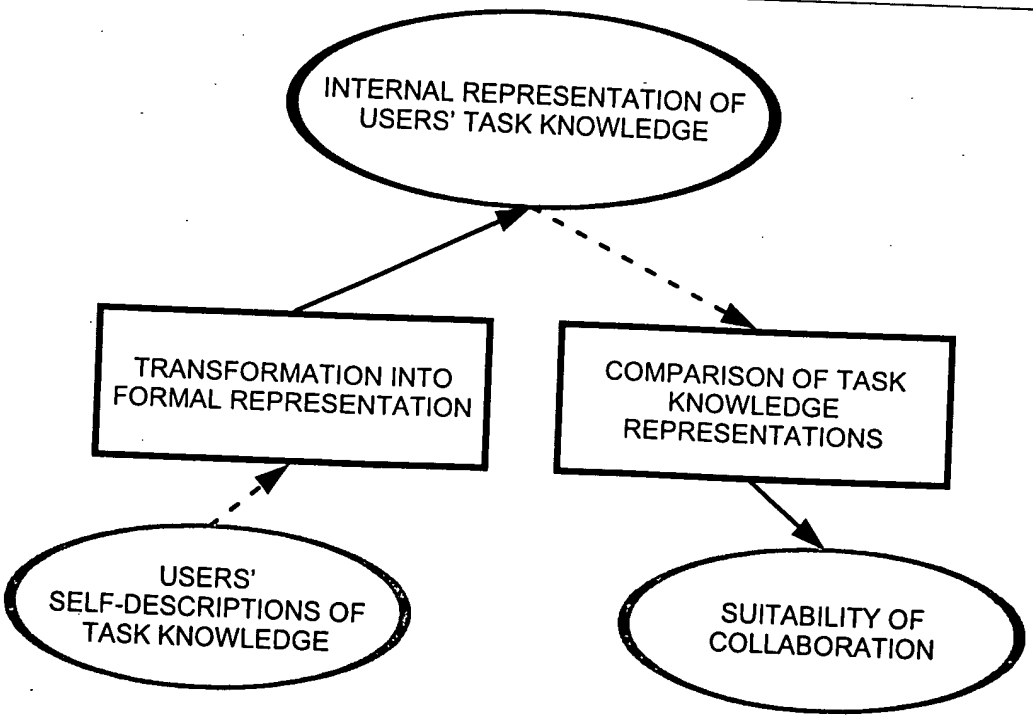
- Part of the Offender Management System used the Correctional Services of Canada

PHelpS suggests helpers who

- are knowledgeable about the problem area of the specific task
- are available to provide help in the time frame required
- have not been overburdened with other help requests in the recent past
- have other relevant positive characteristics (e.g., speaking same language as $\mathcal{U}$)

Overview of Adaptation

94



95

PHelpS: Evaluation (1)

Method

- Subjects: 4 trainees (representative potential users)
- 75 minutes: Introduction to $\mathcal{S}$
- 75 minutes: Performance of realistic simulated tasks
- Trainees in training room; helpers on duty performing day-to-day activities
- Detailed recording of all proceedings

Results

- 7 help requests from trainees
  - $\Rightarrow$ 7 help sessions
  - $\Rightarrow$ 5 successful
- All trainees preferred to choose a knowledgeable peer (as opposed to computer help or a training professional)
- They were not concerned with helper's position in the job hierarchy or whether the helper was known to them

PHelpS: Evaluation (2)

96

Quotations

- "PHelpS is very user-friendly... like step-by-step processing, fully knowing what to do next ... hierarchy is good"
- "... getting the context right is tough"
- "hands-on approach is good ... some staff have more knowledge on certain topics ... it is better to contact them when stuck"
- "... being able to help someone else is helping you"
- "I will contact a knowledgeable stranger to a less knowledgeable friend"
- "Looking forward to seeing it (PHelpS) on the units"

From Greer, J. E., McCalla, G. I., Collins, J. A., Kumar, V. S., Meagher, P., & Vassileva, J. (1998). Supporting peer help and collaboration in distributed workplace environments. *International Journal of AI and Education, 9*, 159-177.http://julita.usask.ca/homepage/Agents.htm

Discussion (1)

Task

- $\mathcal{U}$ identifies persons who can work with $\mathcal{U}$ on a given task

Normal division of labor

- $\mathcal{U}$ considers potential collaborators and assesses their suitability

Division of labor with adaptation

- S compares a characterization of $\mathcal{U}$ with characterizations of potential collaborators and suggests good matches

Relevant properties of $\mathcal{U}$

- Knowledge, interests, ...
- Willingness to collaborate, availability, ...

Discussion (2)

Potential benefits

- $\mathcal{U}$ can save time and find collaborators that couldn't be identified otherwise

Limitations

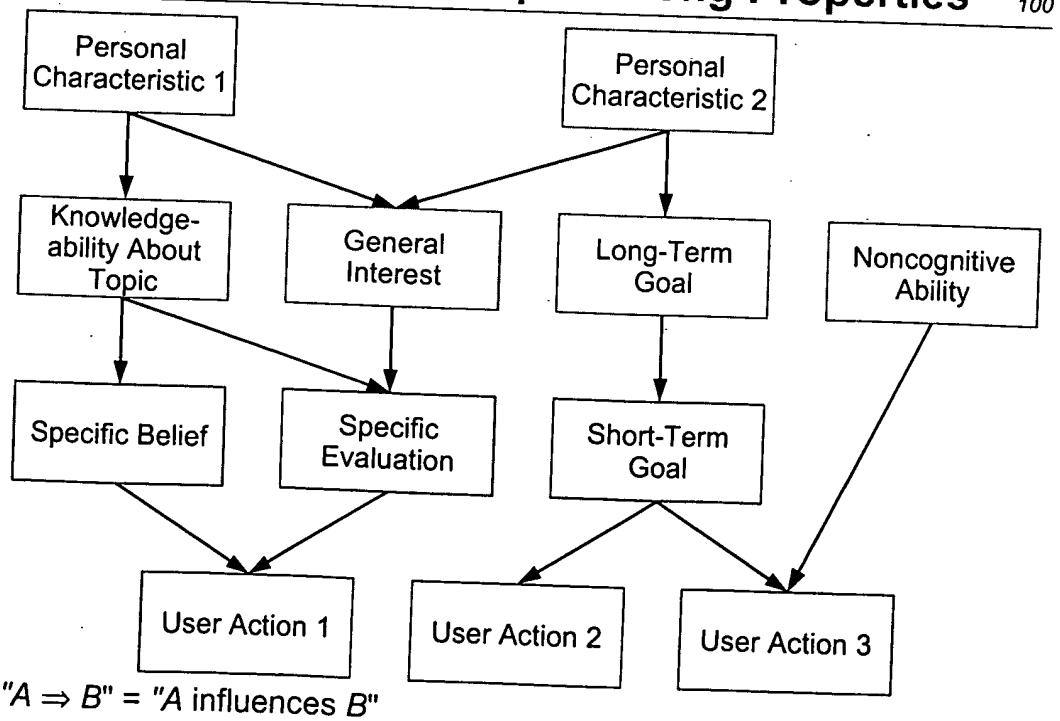
- Because of the greater accessibility of models of users, threats to privacy may be greater
- Especially valuable collaborators may be requested too often, if S is not designed so as to prevent this problem from arising

Properties

99 Overview of Properties Modeled

1. Personal Characteristics
2. General Interests
3. Proficiencies
4. Current Goal
5. Noncognitive Abilities
6. Behavioral Regularities
7. Psychological States
8. Context of Interaction

Typical Relationships Among Properties 100



"$A \Rightarrow B$" = "A influences B"

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Questions About Properties

Breadth of implications

- Is the property $\mathcal{P}$ relevant to a variety of decisions of $\mathcal{S}$ or only to a single type of decision?

Directness of decision-relevance

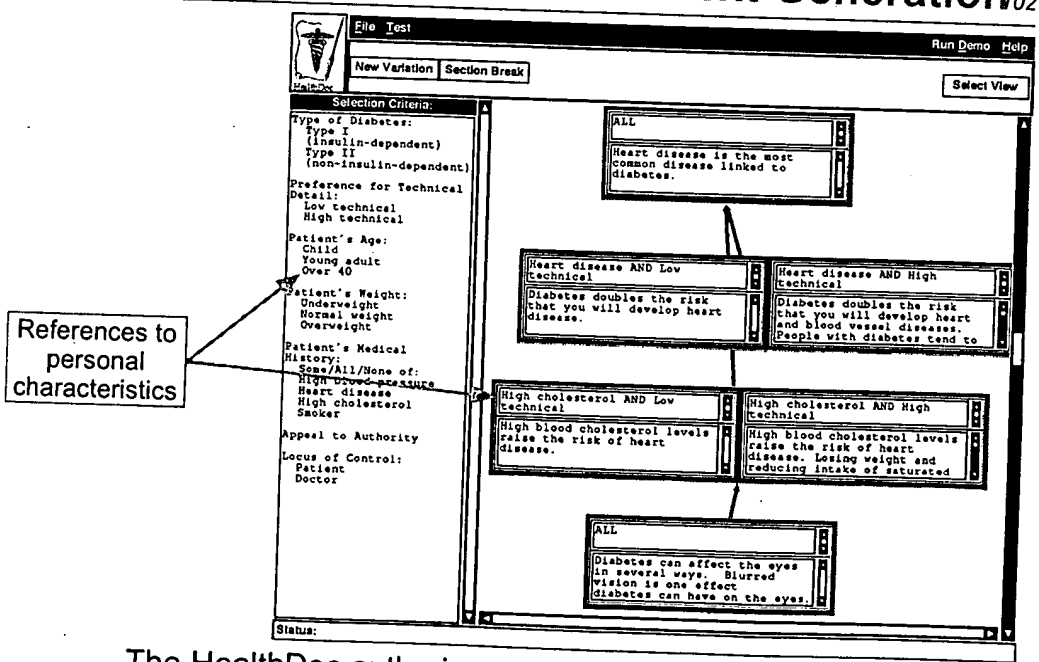
- Can $\mathcal{S}$ take $\mathcal{P}$ into account directly when making a decision, or does $\mathcal{S}$ first have to make (uncertain) inferences on the basis of $\mathcal{P}$?

Ease of assessment

- How difficult is it in general to arrive at a reliable assessment of $\mathcal{P}$?

Personal Characteristics

Personal Characteristics and Text Generation 102



The HealthDoc authoring system supports the generation of personalized medical information documents

Figure 3 from Hirst, G., DiMarco, C., Hovy, E., & Parsons, K. (1997). Authoring and generating health-education documents that are tailored to the needs of the individual patient. In A. Jameson, C. Paris, & C. Tasso (Eds.), *User modeling: Proceedings of the Sixth International Conference, UM97* (pp. 107–118). Vienna: Springer Wien New York. http://www.cs.uni-sb.de/UM97/

Discussion

Breadth of implications

- Often quite high (e.g., for age, gender)

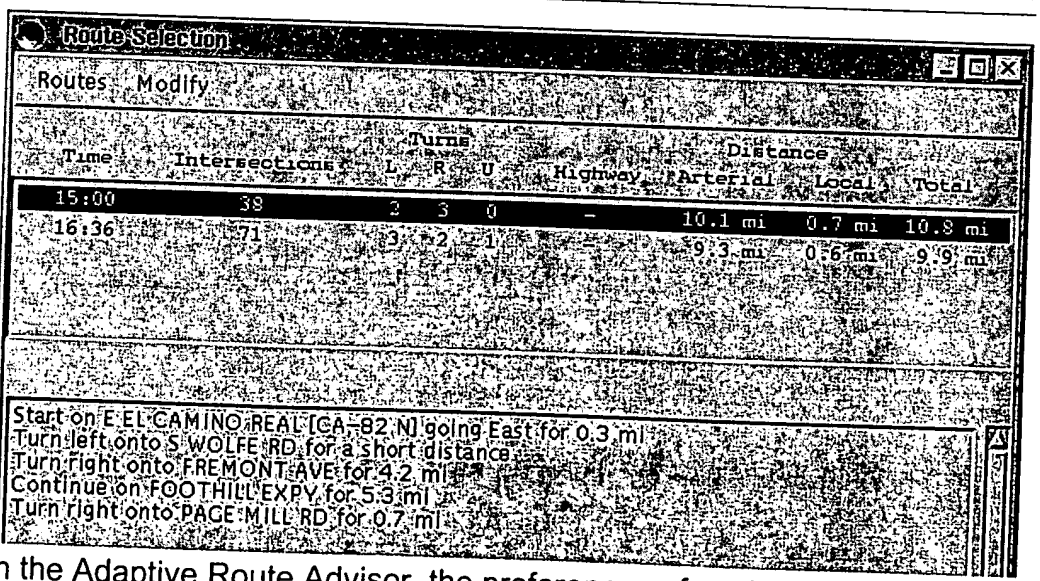
Directness of decision-relevance

- Personal characteristics sometimes have direct, important consequences
  - Example: What type of clothes a customer might want to buy
- But inferences about properties like preferences and knowledge are often unreliable

Ease of assessment

- The necessary information is often already available or easily supplied by $\mathcal{U}$
- Inferring personal characteristics on the basis of indirect evidence is in general difficult

General Interests
Modeling of Evaluation Criteria



In the Adaptive Route Advisor, the preferences of each user $\mathcal{U}$ are represented as a vector of *importance weights*

This vector is used to predict how $\mathcal{U}$ would evaluate any given route if she knew all of its attributes

Figure 3 from Rogers, S., Fiechter, C., & Langley, P. (1999). An adaptive interactive agent for route advice. *Proceedings of the Third International Conference on Autonomous Agents*, Seattle, WA. http://riven.stanford.edu/~rogers/

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Discussion

Breadth of implications

- Generally high

Directness of decision-relevance

- Generally moderate to high

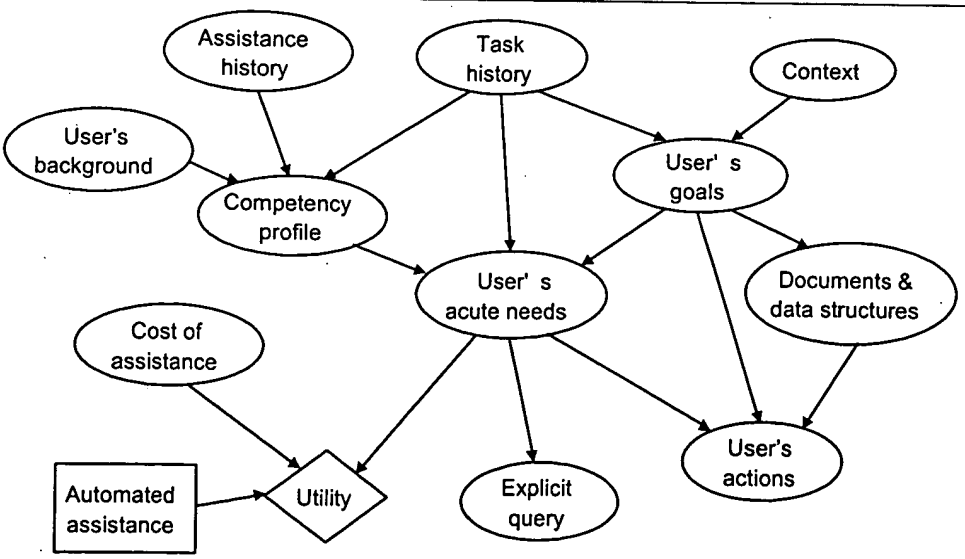
Ease of assessment

- Explicit self-reports can be fairly useful (see below)
- Indirect inference is typically moderately difficult

Proficiencies

Proficiency in Lumiére

106



Lumière's user model referred to an assessment of $\mathcal{U}$s "competency profile" to help judge whether $\mathcal{U}$ needed assistance

(This type of decision-theoretic model will be discussed in the section "Inference")

Figure 2 of Horvitz, E., Breese, J., Heckerman, D., Hovel, D., & Rommelse, K. (1998). The Lumière project: Bayesian user modeling for inferring the goals and needs of software users. In G. F. Cooper & S. Moral (Eds.), *Uncertainty in Artificial Intelligence: Proceedings of the Fourteenth Conference* (pp. 256–265).San Francisco: Morgan Kaufmann. http://www2.sis.pitt.edu/~dsl/UAI/uai.html

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Discussion

Breadth of implications

- The more general the proficiency, the broader the implications

Directness of decision-relevance

- The more general the proficiency, the less direct the implications

Ease of assessment

- Self-reports can be of some use (see below)
- The more general the proficiency, the greater the amount of available indirect evidence
  - But this evidence may not be representative of the overall proficiency
  - Example: $\mathcal{S}$ wants to assess $\mathcal{U}$'s overall knowledge of human-computer interaction, but the available evidence is related only to $\mathcal{U}$'s knowledge of usability evaluation and web page design

Current Goal

Example and Discussion

108

Example

- The previous graphic illustrates how the Lumière prototype probabilistically inferred $\mathcal{U}$'s goals in order to arrive at possible assistance actions

Discussion

Breadth of implications

- Directly relevant only to decisions that $\mathcal{S}$ makes in the current situation

Directness of decision-relevance

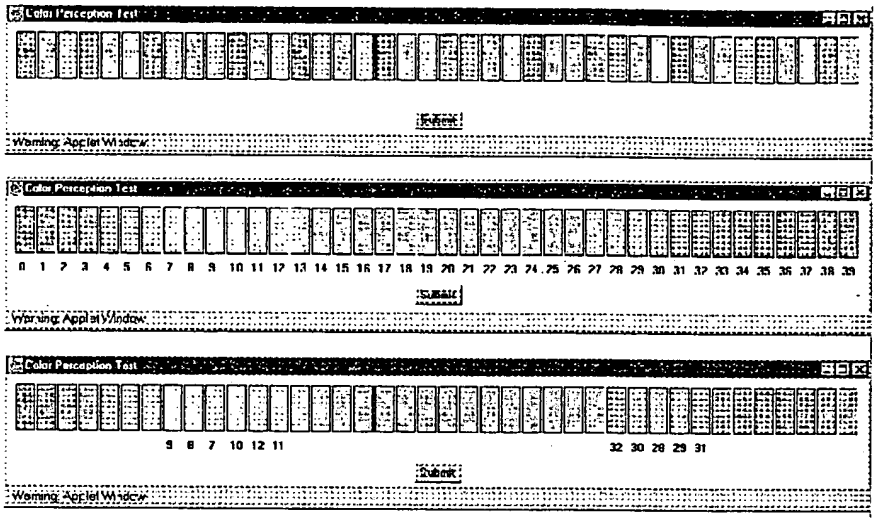
- Generally high

Ease of assessment

- Explicit specification by $\mathcal{U}$ is often too inconvenient
- Indirect inference is typically difficult
  - Observable actions may be compatible with various goals
  - $\mathcal{U}$ may be pursuing more than one goal at a time

Noncognitive Abilities

109 Taking Perceptual Limitations Into Account



The graph critiquing system of Gutkauf et al. (1997) takes $\mathcal{U}$'s perceptual limitations (as determined via tests such as this one) into account

For example, $\mathcal{S}$ tries to ensure that colors which $\mathcal{U}$ cannot discriminate are not used to make distinctions in a graph

Gutkauf, B., Thies, S., & Domik, G. (1997). A user-adaptive chart editing system based on user modeling and critiquing. In A. Jameson, C. Paris, & C. Tasso (Eds.), *User modeling: Proceedings of the Sixth International Conference, UM97* (pp. 159–170).Vienna: Springer Wien New York. http://www.cs.uni-sb.de/UM97/

Discussion 110

Breadth of implications

- Ranges from very high (e.g., generally poor eyesight) to very low (e.g., specific motoric impairment)

Directness of decision-relevance

- Typically quite high

Ease of assessment

- Self-reports are in some cases possible, but often $\mathcal{U}$ wouldn't know how to characterize a noncognitive ability
- Reliable objective tests are often available

Behavioral Regularities

111 Rules Representing $\mathcal{U}$'s Scheduling Habits

Example

Rule learned by the Calendar Apprentice, which helps $\mathcal{U}$ to schedule appointments:

- If
  - Position-of-attendees is Grad-Student, and
  - Single-attendee? is Yes, and
  - Sponsor-of-attendees is Mitchell
- Then
  - Duration is 60 minutes

Comments

There is no reference to the reasons why such a rule may be applicable (or why it may be inapplicable in some cases), e.g.:

- the sort of topic that is typically discussed with graduate students
- Mitchell's attitude toward graduate students
- ...

Mitchell, T., Caruana, R., Freitag, D., McDermott, J., & Zabowski, D. (1994). Experience with a learning personal assistant. *Communications of the ACM*, 37(7), 81–91. http://www.cs.cmu.edu/~tom/publications.html

Discussion

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Breadth of implications

- Low
  - The implications typically concern the particular action that $\mathcal{U}$ would perform in a given situation

Directness of decision-relevance

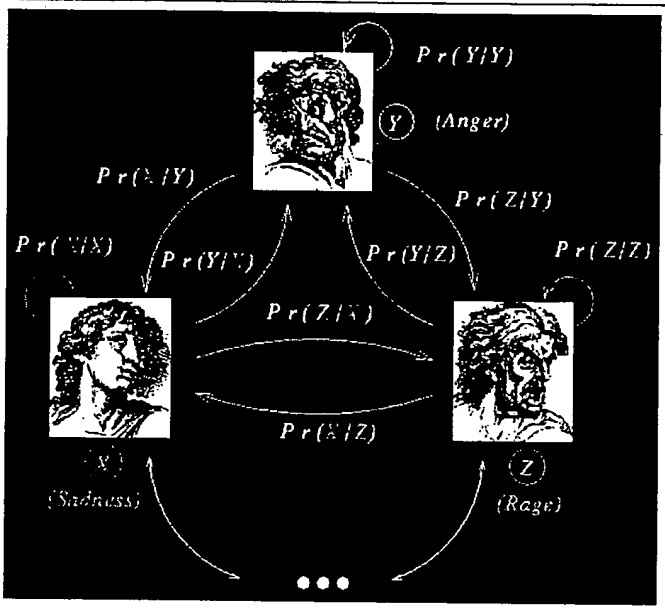
- High, for the same reason

Ease of assessment

- The inference methods are typically straightforward and reliable
- They may require a large amount of behavioral data

Psychological States

113 Transitions Among Emotional States



Affective Computing homepage: http://www.media.mit.edu/affect/. See also Picard, R. W. (1997). *Affective computing*. Cambridge, MA: MIT Press.

Within the Affective Computing paradigm, a variety of methods are used to recognize and predict a user's emotional state

Discussion 114

Breadth of implications

- Relatively low
  - The states are typically of limited duration

Directness of decision-relevance

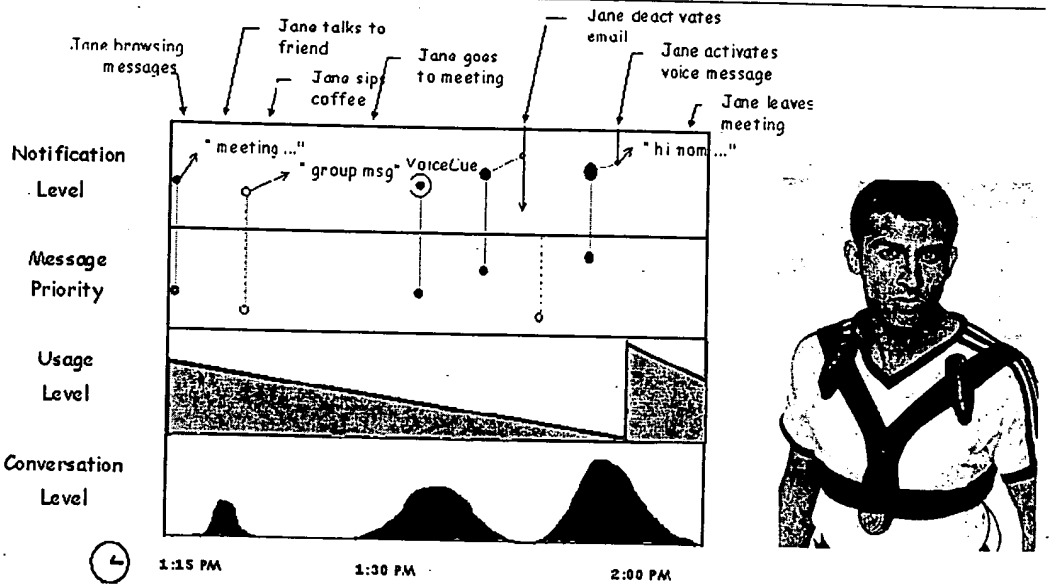
- Often rather low
  - Even if $\mathcal{S}$ knows that $\mathcal{U}$ is frustrated, distracted, or rushed, it may not be obvious how $\mathcal{S}$ should adapt its behavior accordingly

Ease of assessment

- Can be fairly high if suitable sensors are used (see below)
- More tricky if behavioral symptoms must be interpreted

Context of Interaction

115 Context-Sensitivity in Nomadic Radio



Sawhney, N., & Schmandt, C. (1999). Nomadic radio: Scaleable and contextual notification for wearable audio messaging. In M. G. Williams, M. W. Altom, K. Ehrlich, & W. Newman (Eds.), *Human factors in computing systems: CHI '99 conference proceedings* (pp. 96–103). New York: ACM. http://www.media.mit.edu/~nitin/NomadicRadio/ These images come from that web site, which contains many other relevant links

Nomadic Radio takes into account environmental sounds and the intensity of $\mathcal{U}$'s system use in determining how to present incoming information

Discussion

116

Breadth of implications

- Implications are largely limited to the current situation

Directness of decision-relevance

- Implications are often quite straightforward

Ease of assessment

- Some aspects of context are more or less directly accessible to $\mathcal{S}$
  - Example: What applications $\mathcal{U}$ is using
- If appropriate sensors are available (see below), other aspects can be assessed straightforwardly
- In other cases, difficult indirect inferences may be required

Input

Overview of Input Types

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Explicit self-reports and -assessments

1. Self-Reports onPersonal Characteristics
2. Self-Reports on Proficiencies and Interests
3. Evaluations of Specific Objects

Nonexplicit input

4. Responses to Test Items
5. Naturally Occurring Actions
6. Indices of Psychological States
7. Evidence About Context

Questions About Input Types

118

Frequency

- How often is input of the type I typically acquired?

Additional activity

- Does I require extra activity by $\mathcal{U}$ that would not otherwise be required?

Cognitive effort

- How much thinking and memory retrieval does I require from $\mathcal{U}$?

Motor effort

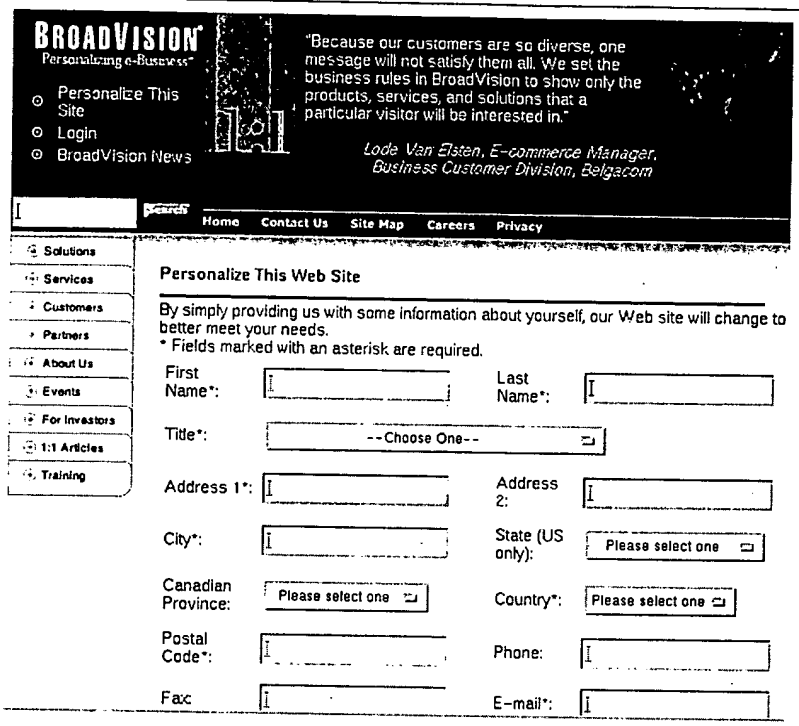
- How much physical input activity (e.g., typing) does I require?

Reliability

- To what extent does I allow S to derive precise, accurate assessments of properties of $\mathcal{U}$?

Self-Reports on Personal Characteristics

119 Personalizing BroadVision's Web Site



Discussion

120

Frequency

- Typically only at one or two points in a dialog

Additional activity

- Usually, there's extra activity
- But in some cases $\mathcal{U}$ might have to supply much of the same information anyway – e.g., to place an order

Cognitive effort

- Generally little

Motor effort

- Often a lot – unless easy copying from other information sources is supported

Reliability

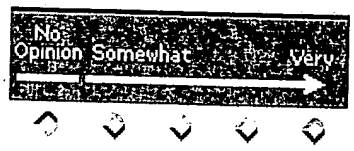
- On the whole high
- But there may be distortions if sensitive issues are involved, or if seldom-used information has to be recalled from memory

Self-Reports on Proficiencies and Interests

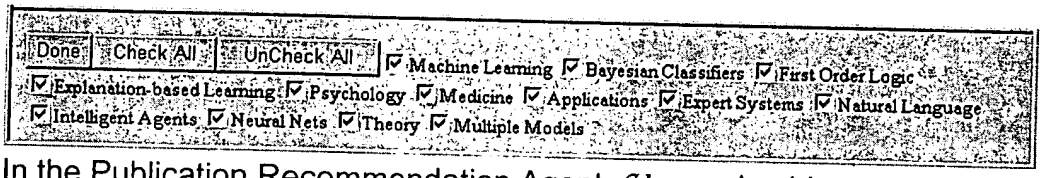
121 Examples (1)

How important to you is a dog that's easy to train?

Some dogs are more stubborn than others. If you want a dog that will learn and obey your commands, place more emphasis here. If you don't plan to teach your dog more than a few tricks, this won't matter much.



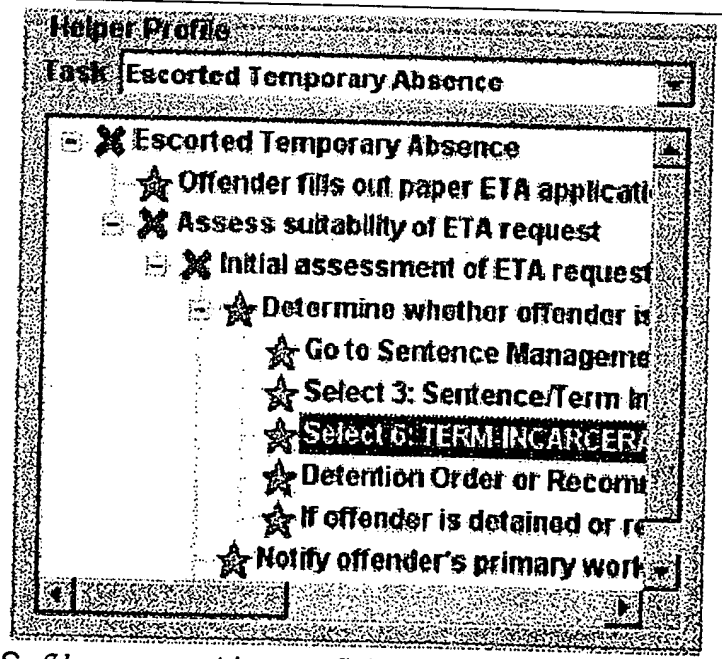
In PersonaLogic, $\mathcal{U}$ often specifies a preference on a 5-point scale



In the Publication Recommendation Agent, $\mathcal{U}$ can give binary self-assessments of a number of interests within a small dialog box

http://www.personalogic.com/; Pazzani, M. J., & Billsus, D. (1999). Evaluating adaptive web site agents. *Proceedings of the Workshop on Recommender Systems Algorithms and Evaluation, 22nd International Conference on Research and Development in Information Retrieval.*

Examples (2)



With PHelpS, $\mathcal{U}$ can report her proficiency at particular tasks at various levels of granularity

Greer, J. E., McCalla, G. I., Collins, J. A., Kumar, V. S., Meagher, P., & Vassileva, J. (1998). Supporting peer help and collaboration in distributed workplace environments. *International Journal of AI and Education, 9*, 159–177.http://julita.usask.ca/homepage/Agents.htm

123

Discussion

Frequency

- Typically only at one or two points in a dialog

Additional activity

- There's almost always extra activity

Cognitive effort

- May be high, if $\mathcal{U}$ tries seriously to give a reliable assessment (see below)

Motor effort

- Little

Reliability

- Sometimes low:
  - $\mathcal{U}$ may not know the exact meanings of the reference points given
  - $\mathcal{U}$ may be motivated to give an inaccurate self-assessment

Evaluations of Specific Objects

Example

124

In the web page recommending system Syskill & Webert, $\mathcal{U}$ can click on the thumbs to indicate interest or disinterest in the page being shown

Figure 1 from Pazzani, M., & Billsus, D. (1997). Learning and revising user profiles: The identification of interesting web sites. *Machine Learning*, 27, 313–331.http://www.ics.uci.edu/~pazzani/Publications/Publications.html

125

Discussion

Frequency

- Typically, many evaluations are given

Additional activity

- Usually, there's some extra activity
  - Though it's not much of a burden in each individual case, the total effort can add up
  - Users often don't bother with even simple evaluations

Motor effort

- Can be reduced to a single mouse click

Cognitive effort

- Low; usually a spontaneous reaction is expressed

Reliability

- Often fairly high
  - The same problems as for general interests may arise to some extent, but the concreteness of the judgment makes it more reliable

Responses to Test Items

Example

126

In principle, it is even possible to call <<+>> without any arguments. (+) returns 0 as its result.

Exercises:

What is the result of the function call
(+ 3) ?

What is the result of the function call
(+) ?

In a learning environment like ELM-ART, tests and exercises simultaneously serve other purposes, in addition to supporting adaptation

(See also the color discrimination test of Gutkauf et al., 1997, presented earlier, which can be presented as a sort of game)

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Discussion

Frequency

- Tests can be administered at a single point, or at regular intervals (as in educational systems)

Additional activity

- If the test items are also used for practice and for learner evaluation, $\mathcal{U}$ may have to deal with them anyway

Cognitive and motor effort

- These depend on the nature of the test

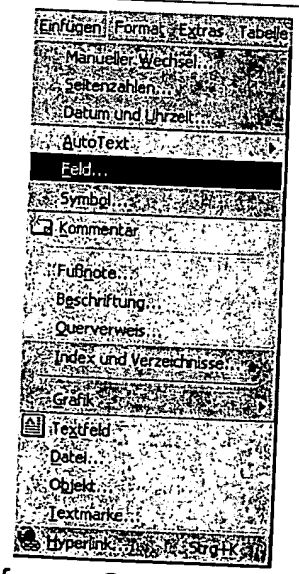
Reliability

- Generally high:
  - Test items can be selected, administered, and interpreted through well-understood, reliable procedures

Naturally Occurring Actions

Example

128



$\mathcal{U}$'s selection of an option from a Smart Menu may reflect the fact that she finds the option useful

But maybe she simply wanted to see what it does –and found it to be of no interest

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Discussion

Frequency

- There may be a great number of relevant natural actions – or only a few if a very specific type is involved

Additional activity

- Usually there's no extra activity
- Sometimes, ostensibly natural actions are invoked by disguised tests

Cognitive and motor effort

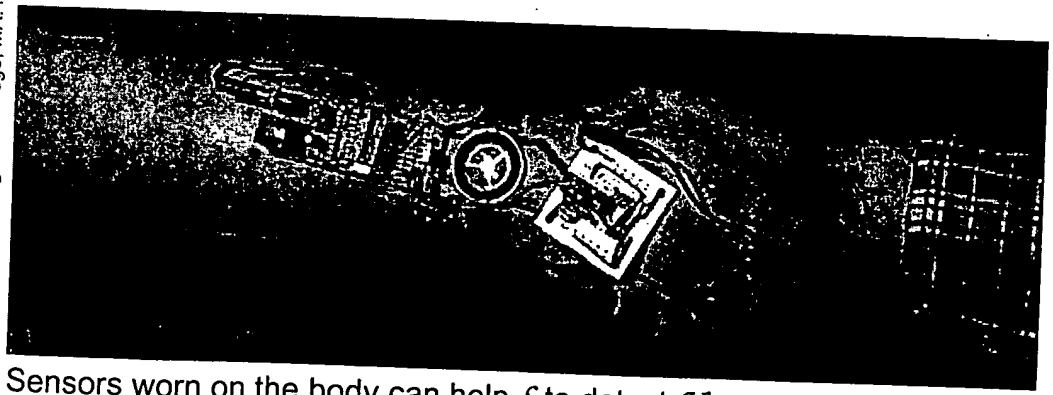
- Can vary greatly; but not very important, since the actions will tend to be performed anyway

Reliability

- Naturally occurring actions can be reliable indicators of specific beliefs and attitudes, but less so of generally relevant properties of $\mathcal{U}$

Indices of Psychological States
Example: Jewelry for Affective Computing

130



Sensors worn on the body can help $\mathcal{S}$ to detect $\mathcal{U}$'s emotional state

Affective Computing homepage: http://www.media.mit.edu/affect/ See also Picard, R. W. (1997). *Affective computing*. Cambridge, MA: MIT Press.

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Discussion

Frequency

- Where the necessary sensors are available, a large amount of input data can be acquired

Additional activity

- Since most people wouldn't wear such sensors otherwise, any associated effort is usually extra effort

Cognitive effort

- Typically none, since $\mathcal{U}$ doesn't have to give any explicit input

Motor effort

- Sensors can be cumbersome, but technological advances are continually reducing the burden

Reliability

- Fairly high for some psychological states that are closely associated with measurable symptoms

Evidence About Context

Example

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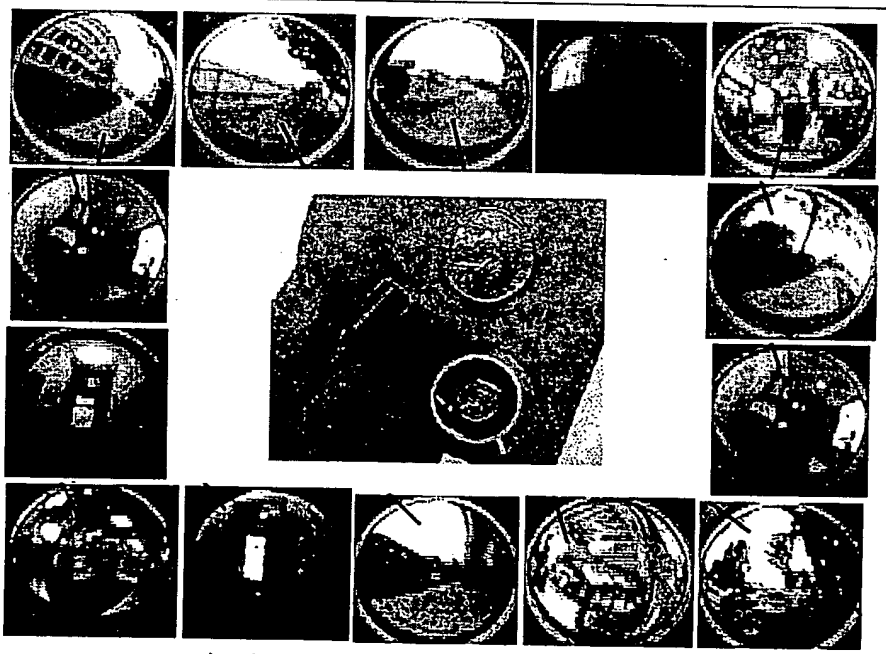

The tiny camera and microphone pick up low-level features of the environment in which $\mathcal{U}$ finds herself at the moment

Schiele, B., Starner, T., Rhodes, B., Clarkson, B., & Pentland, A. (2000). Situation aware computing with wearable computers. In W. Barfield & T. Caudell (Eds.), *Augmented reality and wearable computers*. Mahwah, NJ: Erlbaum. http://www.media.mit.edu/~bernt

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Discussion

Frequency

- The amount of data that can be acquired is limited only by the technological possibilities and the amount of available information that is worth collecting

Additional activity; cognitive and motor effort

- $\mathcal{U}$ may be required to specify some information about the context
- Technological advances make it increasingly possible to acquire enough information without effort by $\mathcal{U}$

Reliability

- Depends on the degree of precision required and on the available technology

Inference

135 Overview of Main Approaches to Inference

1. Classification Learning
2. Social Recommendation
3. Decision-Theoretic Methods
4. Application-Specific Procedures

Classification Learning

Brief Introduction

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Scope

- Large family of techniques in machine learning field
- Various types of models can be used
  - Decision trees, probabilistic classifiers, support vector machines, neural networks, case-based reasoning, vector space representations from information retrieval, ...

Nature of problem

Given

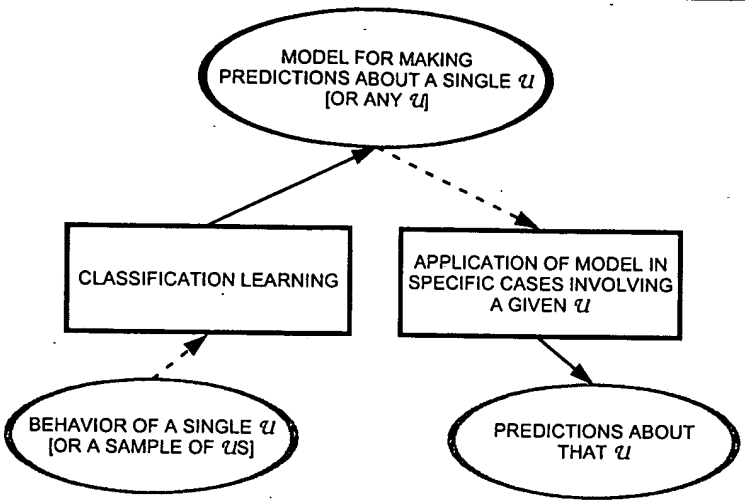
- A set of classified examples
- A *type of model* for classifying individual cases
  - Example: decision trees
- (Optional:) relevant background knowledge

Produce

- A *specific learned model* that accurately classifies previously unseen cases

General texts on machine learning:
Langley, P. (1996). *Elements of machine learning*. San Francisco: Morgan Kaufmann.
Mitchell, T. M. (1997). *Machine learning*. Boston: McGraw-Hill.

137 Overview of Adaptation



The learning may be done for: each individual user, users in general, or some combination of the two

Note that classification often amounts to *prediction*:

"This web page is classified as 'interesting for this $\mathcal{U}$"

⇒ "It is predicted that this $\mathcal{U}$ will be interested in this web page"

Systems That Use Classification Learning (1) 138

SwiftFile

- A distinct model for classifying email messages is learned for each user
- The learning method was designed so that the representation of each folder can be updated quickly when a new message is filed into it

TOOT

- In off-line training, TOOT learned to classify dialogs into the following categories on the basis of features of the initial utterances:
  1. "Good dialog": Percentage of semantic misrecognitions < 11%
  2. "Bad dialog": [All other dialogs]
- There is no additional learning for each individual user
  - The general model is simply applied to each user
- Whenever the current dialog is classified as "bad", $\mathcal{S}$ switches to a more conservative dialog strategy

See the references given in the section "Functions"

139 Systems That Use Classification Learning (2)

Systems that recommend documents

Examples of document types

- Web pages
- News stories delivered via wireless media

Given:

1. Features of documents that $\mathcal{U}$ has seen
   Keywords, words in text, genre, length, language, ...
2. Some indication of how $\mathcal{U}$ liked each document
   Explicit rating, downloading, viewing time ...

Learn:

- Rules for predicting, on the basis of features, which documents $\mathcal{U}$ will like

A well-known example of web page recommendation is Syskill & Webert: Pazzani, M., & Billsus, D. (1997). Learning and revising user profiles: The identification of interesting web sites. *Machine Learning, 27*, 313–331. http://www.ics.uci.edu/~pazzani/Publications/Publications.html The company AdaptiveInfo applies this type of technology commercially: http://www.adaptiveinfo.com/

Discussion 140

What is needed for learning?

1. A set of discrete categories of interest
2. A set of features that in principle could allow $\mathcal{S}$ to discriminate among the categories
3. A reasonably large number of observations for learning
   - For general user models:
     - Observations can be obtained from a large number of users and analyzed off-line
   - For individual user models:
     - It may take a long time to acquire enough data
     - Ways of reducing this time are a key topic of research

What is needed for classification or prediction?

- Information about the features of the current case
  - (Usually not a problem)

Social Recommendation

General Remarks (1)

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Other terms

- *Collaborative filtering*
- *Social information filtering*

Drawbacks of these terms

- The approach is not useful only for routine information filtering
  - Also for processing explicit requests for recommendations
- Active "collaboration" of other users is not required
  - Stored data about their choices are simply exploited

Scope

- The term covers a variety of specific algorithms
- New variants are continually being developed and tested*

*See, for example: Herlocker, J. L., Konstan, J. A., Borchers, A., & Riedl, J. (1999). An algorithmic framework for performing collaborative filtering. *Proceedings of the 1999 Conference on Research and Development in Information Retrieval.* http://www.cs.umn.edu/Research/GroupLens/

General Remarks (2)

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History

- Introduced in the late 1980s and early 1990s
- Now widely used commercially:
  - Best known single application:
    http://www.amazon.com
  - Two of the firms that sell the technology:
    http://www.netperceptions.com
    http://www.likeminds.com

See, e.g., http://www.cs.umn.edu/Research/GroupLens/

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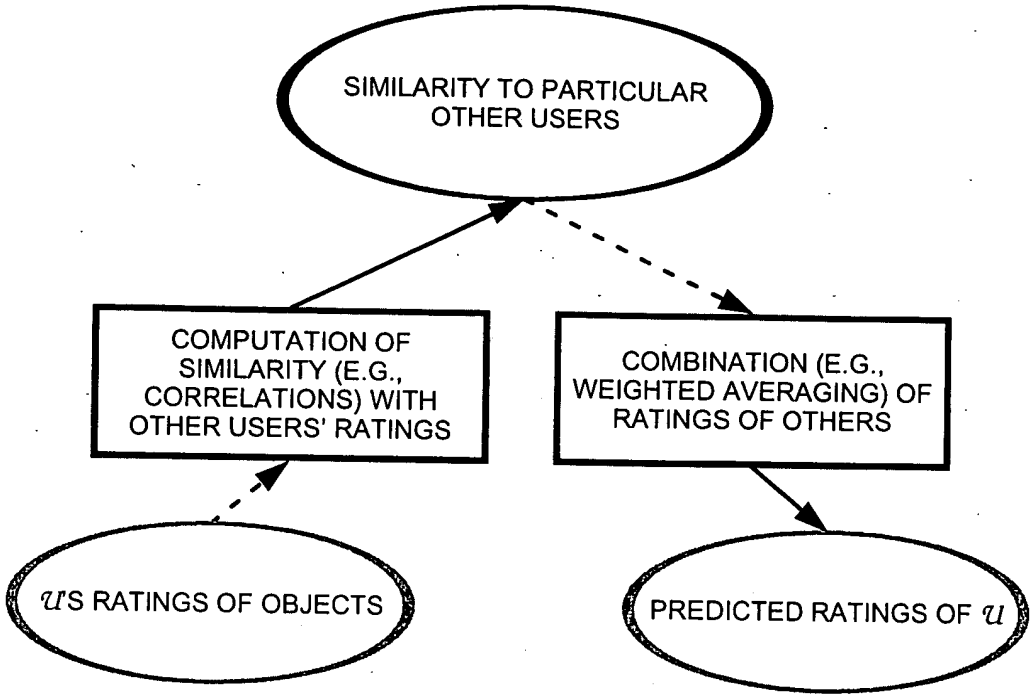
Overview of Adaptation



MovieCentral: Summary of Procedure

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Identifying mentors

1. Store $\mathcal{U}$'s ratings of movies
2. For each $\mathcal{U}^*$ in a sample of other users, compute an *agreement strength* with $\mathcal{U}$ on the basis of
   - difference between ratings of $\mathcal{U}^*$ and $\mathcal{U}$
   - number of objects rated by both $\mathcal{U}^*$ and $\mathcal{U}$
3. Identify a set of *mentors* for $\mathcal{U}$ on basis of
   - agreement strength with $\mathcal{U}$
   - total number of objects rated
   - extension of total item coverage

Making predictions and ratings

4. For each item, use mentors' ratings to compute
   - predicted rating by $\mathcal{U}$
   - confidence in prediction
   - disagreement among mentors
5. Base predictions and recommendations on these factors

Greening, D. R. (2000). *Building consumer trust with accurate product recommendations: A white paper on Macromedia's LikeMinds personalization technology.* Boston: Macromedia. http://www.macromedia.com/

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Discussion

What can it provide?

- Predictions as to how a $\mathcal{U}$ will respond to a given set of objects O

What is needed?

- Database with ratings by many users of many objects
  - Ratings are usually explicit, but they may be implicit
- For each object O, at least some ratings in this database should concern O
  - Hard to fulfill when new objects continually enter database
- Moderate number of ratings of various objects by the current $\mathcal{U}$
  - Until these are obtained, $\mathcal{U}$ can perhaps be kept satisfied with recommendations derived by other means

Other limitations

- In the basic procedure, no straightforward way for $\mathcal{U}$ to express preferences directly
  - Example: "I don't like science fiction movies!"

Decision-Theoretic Methods

Influence Diagram from Lumière

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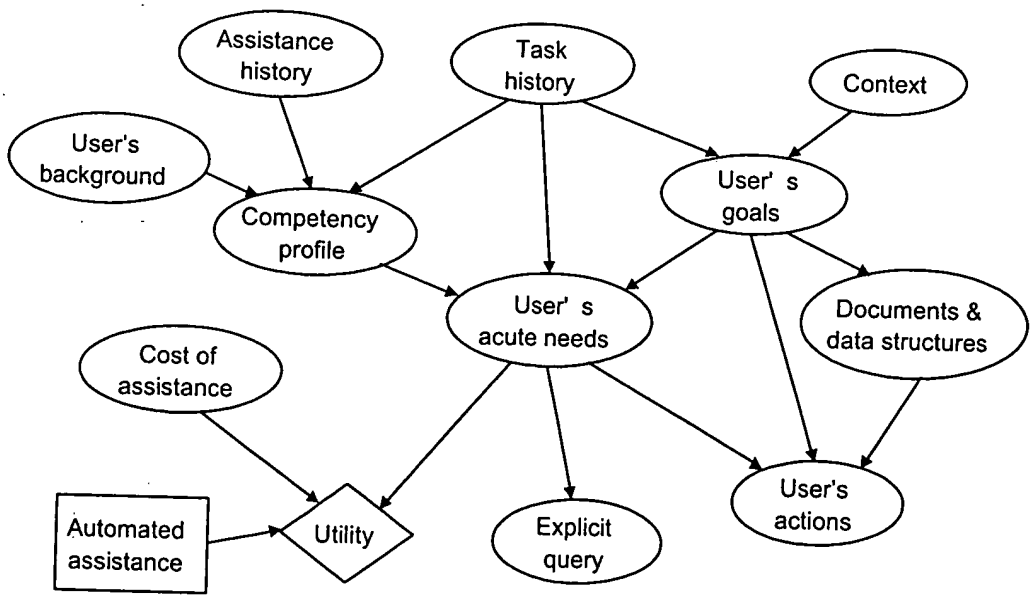

"Automated assistance" is a decision node, "Utility" a value node; the others are chance nodes

Figure 1 of Horvitz, E., Breese, J., Heckerman, D., Hovel, D., & Rommelse, K. (1998). The Lumière project: Bayesian user modeling for inferring the goals and needs of software users. In G. F. Cooper & S. Moral (Eds.), *Uncertainty in Artificial Intelligence: Proceedings of the Fourteenth Conference* (pp. 256–265). San Francisco: Morgan Kaufmann. http://www2.sis.pitt.edu/~dsl/UAI/uai.html

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Basic Concepts

Bayesian networks

- Each *chance node* in a Bayesian network (BN) corresponds to a variable
  - In user-adaptive systems, most variables refer to properties of $\mathcal{U}$
  - These may be observable or unobservable
- $\mathcal{S}$'s *belief* about each variable is represented as a probability distribution
- Links between nodes typically represent causal influences
- When the value of a variable is observed, the corresponding node is *instantiated*
  - The *evaluation* of the BN then leads to revised beliefs about the other variables

Extension to influence diagrams

- An *influence diagram* also contains *decision nodes* and *value nodes*
- Through the evaluation of an influence diagram, $\mathcal{S}$ can determine which decision is likely to yield the highest value

A classic exposition is: Pearl, J. (1988). *Probabilistic reasoning in intelligent systems: Networks of plausible inference.* San Mateo, CA: Morgan Kaufmann. Uses within user-adaptive systems are discussed by: Jameson, A. (1996). Numerical uncertainty management in user and student modeling: An overview of systems and issues. *User Modeling and User-Adapted Interaction, 5,* 193–251.http://www.cs.uni-sb.de/users/jameson/

Discussion

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What are these methods especially good for?

- Deriving explicitly uncertain beliefs on the basis of limited, unreliable evidence
  - Example: $\mathcal{U}$ has made a single mistake; what does it imply?
- Systematically handling tradeoffs between competing system goals
  - Examples: Offer $\mathcal{U}$ help; don't distract $\mathcal{U}$ from work
- Making explicit the considerations underlying $\mathcal{S}$'s inferences and decisions

What is needed to build the models?

- One or both of:
  - Knowledge about causal relationships and probabilities
  - Data for automatically learning causal relationships and/or probabilities

What is needed in use?

- Even one piece of unreliable evidence can give rise to a useful inference or decision

See also Jameson, A. (1996). Numerical uncertainty management in user and student modeling: An overview of systems and issues. *User Modeling and User-Adapted Interaction, 5,* 193–251. http://www.cs.uni-sb.de/users/jameson/

Application-Specific Procedures

149

General Comments

Types of application-specific procedures

Hand-coded rules

- The designer simply specifies, in some formalism, what S is supposed to do in particular circumstances
- Possible bases:
  - Input from domain experts
  - Designer's own experience, common sense

Computational procedures

- The designer specifies some sort of formula or algorithm for making predictions or decisions
- Possible bases:
  - Quantitative cognitive model
  - Off-line statistical analysis of data

Examples of Hand-Coded Rules

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The use of these rules may be coupled with application-specific representations of information

Cancer system

- If U has asked for information on her "problems"
  - Then dynamically generate a page on the basis of U's medical record

ELM-ART

- If U has shown she is familiar with concept C
  - Then no longer discourage U from visiting pages that presuppose knowledge of C

Smart Menus

- If U has selected option O in menu M at least once
  - Then include O in the main part of M from now on

See the references given in the section "Functions"

151 Example of a Computational Procedure

Recommendation of Sears and Shneiderman (1994) concerning split menus

- To decide whether to move a given option into the high-frequency section of a split menu:
  - Compute the *expected benefit* of doing so according to
    [a formula based on a cognitive model of menu selection]
  - Determine whether the expected benefit exceeds a given threshold

Note

- The authors presumably would not advocate using the formula to change a menu during an interaction
  - It does not take the costs of adjustment by $\mathcal{U}$ into account

Discussion 152

When are application-specific procedures best?

- For many simple, straightforward inferences and decisions:
  - Easy to implement
  - Easy to communicate about (if simple)

When should more powerful techniques be used?

- When problems are more complex:
  - Large number of features to consider
  - High degree of uncertainty
  - Quantitative tradeoffs
  - Relationships that can be empirically determined but that are not obvious a priori

Are the more powerful methods hard to work with?

- In many cases, available software packages make implementation fairly straightforward

User Studies

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Overview

1. Wizard of Oz Studies
2. Simulations With Existing Data
3. Controlled Studies
4. Studies of Actual System Use

Focus

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Applicability of standard empirical methods

- Familiar HCI empirical methods are also applicable to user-adaptive systems
- Possible reasons for infrequent use
  - Designers often trained in other areas than HCI or psychology (e.g., artificial intelligence)
  - Frequently great effort needed to get a user-adaptive system to adapt reasonably in the first place

Focus in this tutorial

- Here, we focus on issues and methods that are (relatively) specific to user-adaptive systems

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Questions of Special Interest

Accuracy of modeling

- $\mathcal{S}$ typically derives testable predictions about each individual user $\mathcal{U}$
- Reasonable accuracy of the predictions is usually a necessary (though not sufficient) condition for overall success
- It can be hard to know the implications of overall usability results if the accuracy of the modeling is not known
- Also, how *fast* $\mathcal{S}$ attains accuracy for a given $\mathcal{U}$ may be important

User acceptance of adaptive features

- Problems of control, predictability, and appropriate timing may be most clearly reflected in
  - Subjective ratings
  - Ignoring or turning off adaptive features

Wizard of Oz Studies

Wizard of Oz Study for Lumière (1)

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Method

Subjects

- Were told an experimental help system would track their activity and make guesses about how to help them
- Received the advice via a computer monitor

Experts

- Worked in a separate room
- Viewed subjects' activity via a monitor
- Conveyed advice by typing
- Were not informed about the assigned spreadsheet tasks

Summarized on the basis of pp. 258 of Horvitz, E., Breese, J., Heckerman, D., Hovel, D., & Rommelse, K. (1998). The Lumière project: Bayesian user modeling for inferring the goals and needs of software users. In G. F. Cooper & S. Moral (Eds.), *Uncertainty in Artificial Intelligence: Proceedings of the Fourteenth Conference* (pp. 256–265). San Francisco: Morgan Kaufmann. http://www2.sis.pitt.edu/~dsl/UAI/uai.html

157 Wizard of Oz Study for Lumière (2)

Results

Difficulty of experts' task

- Experts showed some ability to identify $\mathcal{U}$'s goals and needs
- They were often uncertain about
  - $\mathcal{U}$'s goals – sometimes recognized with an "Aha!" reaction after a period of confusion
  - the value of providing different kinds of assistance

Consequences of poor advice

- Users typically examined advice carefully
- Even when advice was off the mark, subjects would often become distracted by it and begin to experiment with the features described
- This behavior gave experts false confirmation of successful goal recognition
- Experts then gave further advice along the same lines

Wizard of Oz Study for Lumière (3) 158

Results (continued)

How experts improved

- Experts became more skillful in offering advice in this situation
- For example, they learned to give conditional advice:
  - "If you are trying to do *X*, then..."

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Discussion

General idea of Wizard-of-Oz

- A human takes over some aspects of $\mathcal{S}$'s processing
- $\mathcal{U}$ may believe the system is fully computerized

Assessing accuracy

+ Can yield an *upper-bound* estimate of the accuracy that is attainable given the available information
  - If humans are better than any likely system
- − May say little about *actually attainable* accuracy levels

Assessing acceptance

+ Some acceptance issues can be investigated much more cheaply than with an implemented prototype
  - Example: Whether users find $\mathcal{S}$'s adaptations basically helpful
- − Acceptance may depend strongly on details not included in the study
  - Example: Distractingness of a lifelike agent's appearance and behavior

Simulations With Existing Data

Suggestion Accuracy of SwiftFile

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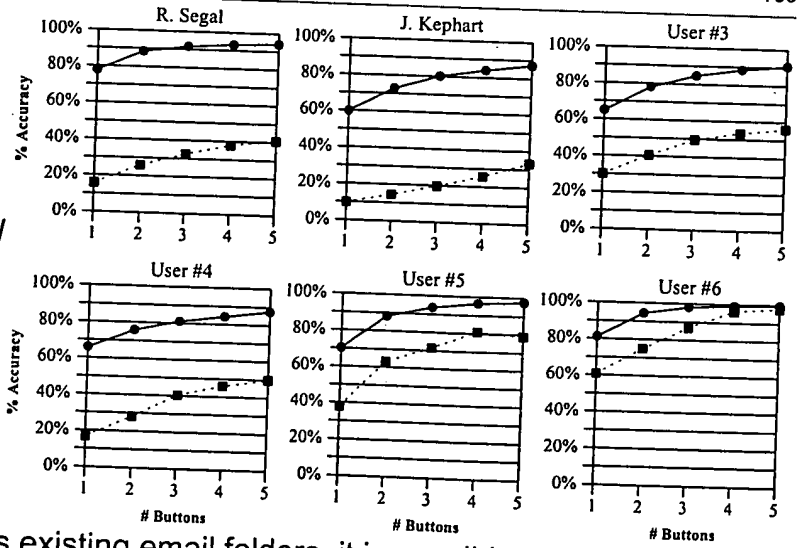
Upper curves: SwiftFile

Lower curves: Presentation of *N* most frequently used folders



Given just a user's existing email folders, it is possible to determine retroactively how accurate SwiftFile would have been in predicting the folder of each new message

The simulation can be performed for several variants of $\mathcal{S}$ (e.g., different numbers of "buttons" that suggest folders)

Figure 3 from Segal, R. B., & Kephart, J. O. (1999). MailCat: An intelligent assistant for organizing e-mail. *Proceedings of the Third International Conference on Autonomous Agents*, pp. 276–282. http://www.research.ibm.com/swiftfile/

161 Discussion (1)

Basic idea

Given

- Detailed behavioral data on system usage by a number of users

Procedure

1. Simulate a use situation in which $\mathcal{S}$ receives the data incrementally as input
2. Check how fast and well $\mathcal{S}$ can
   - Learn the necessary model of $\mathcal{U}$ (where applicable)
   - Make predictions about $\mathcal{U}$

Discussion (2) 162

Assessing accuracy

+ Precise, thorough analyses can be performed without investment of users' time
+ Alternative versions of $\mathcal{S}$ can be compared on the basis of the same data
  - Alternative learning or inference procedures
  - Alternative system behaviors (e.g., number of "buttons" offered)
− The influence of $\mathcal{S}$'s adaptations on $\mathcal{U}$'s behavior cannot in general be taken into account
  - Yet $\mathcal{U}$ may be more difficult (or easier) to model when $\mathcal{U}$ is interacting with an adaptive system

Assessing acceptance

− In general, there are no results concerning acceptance (aside from indirect implications of accuracy)

Controlled Studies

163 Nonadaptive vs. Adaptive TOOT (1)

Subjects and dialogs

- 6 novice users with each system version (nonadaptive, adaptive)
- 4 dialogs with each user

Number of dialogs in which dialog strategy was actually changed by S:

- 19 out of 24

Frequency of adaptation per subject

Number of dialogs per subject with adaptations (out of 4 dialogs)	Number of subjects
4	3
3	1
2	2
1	0
0	0

Nonadaptive vs. Adaptive TOOT (2)

Overall indices

Evaluation Measure	Nonadaptive *S*	Adaptive *S*	*p*
Objective indices:			
Task success	23%	65%	.01
Number of misrecognized turns	6.0	3.9	.15
Number of system turns	17.4	13.7	.28
Subjective indices:			
Self-perceived user "expertise" (1 to 5)*	3.2	4	.09
Overall user satisfaction (8 questions, including "expertise")	21.6	25.6	.20

*"Expertise": "Did you know what you could say at each point of the dialog?"

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Discussion (1)

Procedure and benefits

- The basic motivation, design and interpretation are the same as with many controlled studies of nonadaptive systems
- Typically a nonadaptive and an adaptive variant of S are compared (perhaps with various levels or types of adaptivity)

Assessing accuracy

+ Precise, quantitative accuracy assessments may be possible

− The accuracy of the adaptive version may not be assessable

  Example: When S adapts in order to avoid a potential problem, it may be hard to determine whether the problem would have occurred without adaptation

− Accuracy that is attained only after a long period of use may not be assessed

Discussion (2)

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Assessing acceptance

+ Precise comparisons can be made with a variety of indices of acceptance (subjective and objective)

− Indices involving willingness to use adaptive features may be excluded, if subjects are required to use an adaptive or a nonadaptive variant

− Factors that may strongly influence the desire for adaptive features (positively or negatively) may be absent in the controlled setting:

- Time pressure
- Complexity of the entire set of tasks being dealt with
- Focus on the content of a personally significant task
- Availability of alternative systems (perhaps "one click away")

Studies of Actual System Use

167 Evaluation of Cancer Information System (1)

Subjects

- 525 patients recruited at start of a course of radical radiotherapy treatment

System use

- During initial consultation session
- (Optional:) In waiting room before subsequent treatments

Adaptation

- No adaptation within sessions
- Information presented changes only when medical record changes
- So the comparison is between *nonpersonalized* and *personalized* information presentation

Cawsey, A. J., Jones, R. B., & Pearson, J. (2000). The evaluation of a personalised health information system for patients with cancer. *User Modeling and User-Adapted Interaction, 10*, 47–72.

Evaluation of Cancer Information System (2) 168

Patients' evaluation of information presented

Question asked	General (%)	Personal (%)	Difference (%)	*p*
Positive aspects:				
Was information useful?	60	70	+10	0.16
Did it tell you anything new?	50	64	+14	0.05
Was information relevant?	66	85	+19	0.004
Find information easily?	85	89	+4	0.41
Negative aspects:				
Feel overwhelmed with info?	29	23	−6	0.41
Was it too technical?	14	8	−6	0.23
Was it too limited?	56	41	−15	0.04
Overall index:				
[Satisfaction score > 2?]	26	42	+16	0.04

169 Evaluation of Cancer Information System (3)

Marginal tendencies favoring personalized version

- More use of computer after first session
- More widespread preference for using computer vs. consulting specialist nurse or radiographer
- Greater tendency to look at printouts of session at home

Open question

- Patients using personalized version received:
  1. personalized explanations of medical topics
  2. a basic summary of their medical record
- Might the positive results be due solely to the second difference?

Cautious conclusion

- Linking general information to the reader's own situation may enhance motivation to process that information

Discussion 170

Assessing accuracy

+ Accuracy can be assessed if suitable behavioral indices are available
  - Example: $\mathcal{S}$ makes suggestions, $\mathcal{U}$ chooses whether to adopt them

− Behavioral measures can be misleading
  - Example: $\mathcal{U}$ may follow suggestions of $\mathcal{S}$ simply because it requires less effort to do so; the index of $\mathcal{S}$'s prediction accuracy is then inflated

− As with controlled studies, evidence on accuracy may not be available

Assessing acceptance

+ Typically, there is valuable subjective and objective information on the acceptance of adaptation

− This information may come too late to influence fundamental aspects of the design

Workshop

171 Procedure for Workshop Sessions (1)

At beginning of Session 1

- Groups of about 4–5 participants are formed

During Sessions 1–6

- Goal for session is explained briefly by instructor
- Each group works out ideas using flip chart
  - Refer to the screen shots from the CHI 2001 site (in the next section of the tutorial materials)
- Ideas from some or all groups are reported to all participants and collected by instructor
  - Any groups not heard from in a given session will report first in the subsequent session

Procedure for Workshop Sessions (2) 172

During Session 7

- Ideas are integrated into a coherent proposal for CHI 2002 (insofar as time permits)

After the tutorial

- Presenter edits the proposal into a form suitable for presentation to CHI 2002 organizers

Session 1: Functions (1)

Session Goal (1)

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Group work continues until:
Reports from groups continue until:

From among the three types of adaptation considered so far, think of one type that might be useful in the context of the CHI web site:

1. Sketch a scenario in which this type of adaptation is applied to a site visitor
   - Use telegraphic text and perhaps a drawing or two
2. Make some notes about the extent to which problems of controllability might arise in this scenario

For now, *don't* worry about how $\mathcal{S}$ might acquire the necessary information about $\mathcal{U}$, unless some interesting ideas occur to you

- Assume that $\mathcal{S}$ is able to make the necessary judgments about $\mathcal{U}$ with a useful degree of accuracy
- The main questions now are how the adaptation would look, and what benefits and drawbacks it might have

Session Goal (2)

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Possible examples

Feel free to ignore the hints if you already have ideas of your own

Help $\mathcal{U}$ to Find Information

- An agent helps $\mathcal{U}$ to identify interesting presentations in the Technical Program

Tailor Information to $\mathcal{U}$

- The information presented on certain pages (e.g., the introductory page) is adapted to particular properties of $\mathcal{U}$

Recommend Products

- $\mathcal{S}$ helps $\mathcal{U}$ to find a suitable hotel
- Note: If the approach exemplified by MovieCentral doesn't seem appropriate, consider having $\mathcal{S}$ base its recommendations on
  - Explicitly expressed evaluation criteria of $\mathcal{U}$ (as with PersonaLogic)
  - Evaluation criteria inferred from particular information about $\mathcal{U}$

Notes (1)

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Notes (2)

Session 2: Functions (2)

Session Goal (1)

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Group work continues until:
Reports from groups continue until:

The six functions of adaptation just discussed have less obvious applicability to the CHI web site than the first three functions

Still, with some imagination you should be able to find a potentially useful application for one of these types of adaptation:

1. As in Session 1, sketch a scenario in which this type of adaptation is applied to a site visitor
2. Once again, consider the extent to which problems of controllability might arise

Session Goal (2)

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Possible examples

Help With Routine Tasks

- For the frequent site visitor, $\mathcal{S}$ offers shortcuts to specific pages that $\mathcal{U}$ is likely to want to visit

Adapt an Interface

- Are there elements of page layout that might be adapted automatically to users with perceptual or motor limitations?

Give Help

- Are there parts of the site where $\mathcal{U}$ might need help in performing a task (other than finding relevant information)?
  - Uploading a submission
  - Registering for the conference or for accommodation

Notes (1)

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Notes (2)

Session 3: Properties

Session Goal (1)

Group work continues until:
Reports from groups continue until:

Please address the following questions in relation to *one* of the two scenarios you have worked on in the previous sessions

If you finish early, you can consider the other scenario as well

1. What types of user properties should $\mathcal{S}$ take into account in order to realize the type of adaptation in question?
   - Consider not only the most obvious ones but also any others that might influence the success of the adaptation
     - For example, if $\mathcal{S}$ spontaneously offers advice, $\mathcal{S}$ might take into account $\mathcal{U}$'s context information such as the nature of the task that $\mathcal{U}$ is working on
   - List relevant properties even if you think it would be hard for $\mathcal{S}$ to assess them

Session Goal (2)

2. For each property listed, note briefly what types of information $\mathcal{S}$ might use in assessing this property of $\mathcal{U}$
   - For now, you can use your general computer experience in answering this question
   - We will look at this issue more systematically in the next two sections of the tutorial

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Notes (1)

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Notes (2)

Session 4: Input

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Session Goal

Group work continues until:
Reports from groups continue until:

Again, please address the following question in relation to *one* of the scenarios you have worked on so far

- Design a particularly appropriate or novel way of obtaining information about the user that could be used as a basis for adaptation
  - All of the types of input discussed are potentially relevant, though some may only become technically feasible in later years
  - If you choose a familiar type of input element (e.g., a rating scale) or an obvious type of naturally occurring action (e.g., web page visits), try to introduce some appropriate innovative element
  - You may wish to illustrate your idea with a drawing (large enough to show to all participants using the flip-chart)

Notes (1)

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Notes (2)

Session 5: Inference

Session Goal

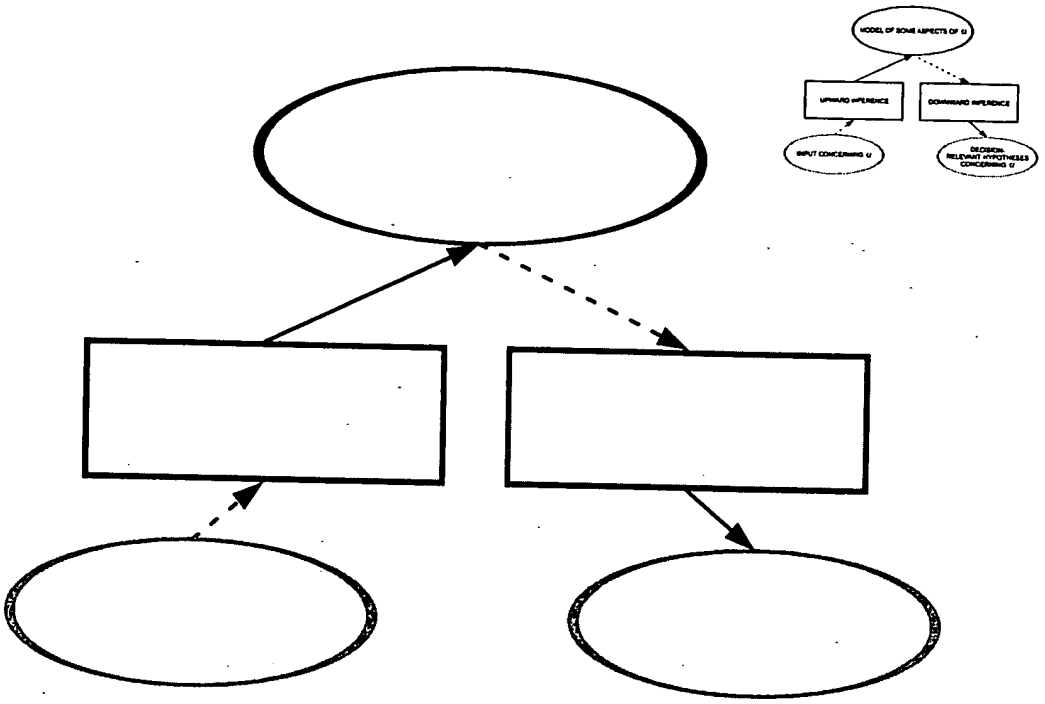
Group work continues until:
Reports from groups continue until:

Consider some inference task that S must perform in one of the scenarios you have worked on

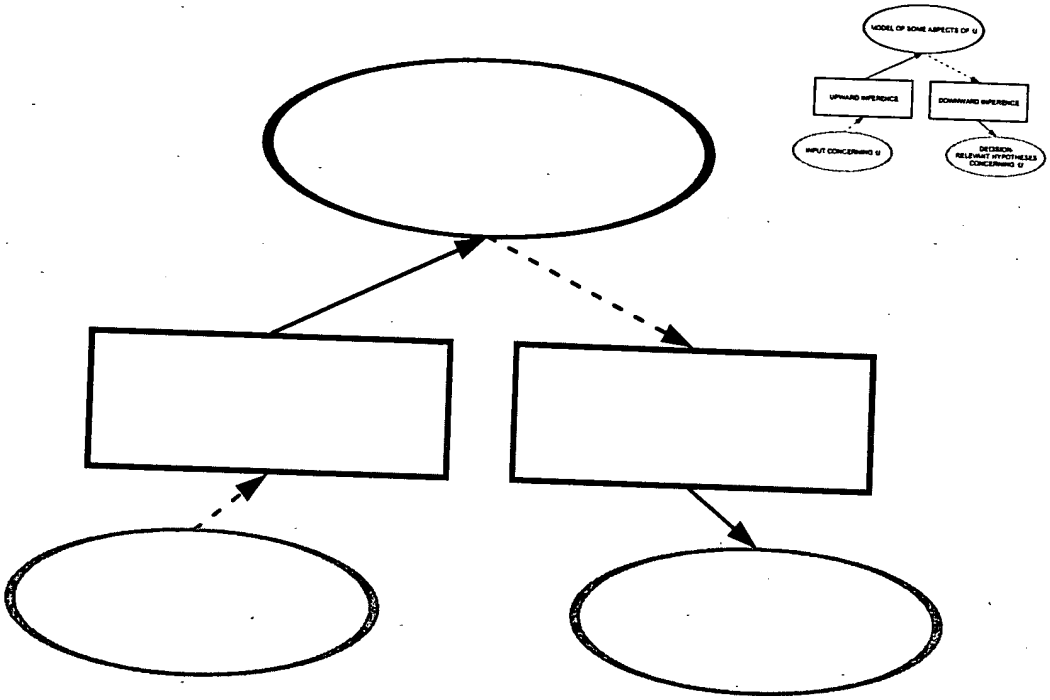
1. Decide which of the four broad approaches to inference seems most appropriate for this task
2. Outline how the inference task could be handled by filling in our basic inference schema in a fairly concrete way
   - Two blank schemas are provided on the next two pages for your notes

Notes (1)

Notes (2)



Notes (3)


MODEL OF SOME ASPECTS OF U
UPWARD INFERENCE
DOWNWARD INFERENCE
INPUT CONCERNING U
DECISION RELEVANT HYPOTHESES CONCERNING U

Session 6: User Studies

Session Goal

Group work continues until:
Reports from groups continue until:

Here, you may be able to consider simultaneously more than one of the types of adaptation that you have worked on so far

1. Choose a type of empirical study that would be especially suitable for evaluating the adaptation you have in mind
2. List the main features of the study, including the following points:
   - Which variant(s) of S will be employed?
   - What indices of success will be used?
3. What are the main questions that you expect to be answered?
   - In particular, is the focus mainly on accuracy, acceptance, or some other issue?

Notes (1)

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Notes (2)

Session 7: Synthesis

Session Goal

This final session is a plenary session

We will review the proposals that have been discussed and select a set which

- seem most promising, after all aspects have been considered
- can be integrated into a fairly coherent high-level design proposal
  - Including ideas about how the system is to be implemented and evaluated

During the last few minutes, we will discuss any general issues that are raised by participants

Notes (1)

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Notes (2)

Notes (3)

CHI 2001 Site

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Introduction

- This section shows a representative sample of pages from the (nonadaptive) web site for CHI2001
  - Date of screen shots: Beginning of January, 2001
- The pages are intended to support concrete discussion of how adaptive features could be introduced into the corresponding web site for CHI 2002
- The pages appear here in the same order as in the site map (see next page)
- During the workshop sessions, each group will probably choose to focus on a small number of aspects of the site

Home Page

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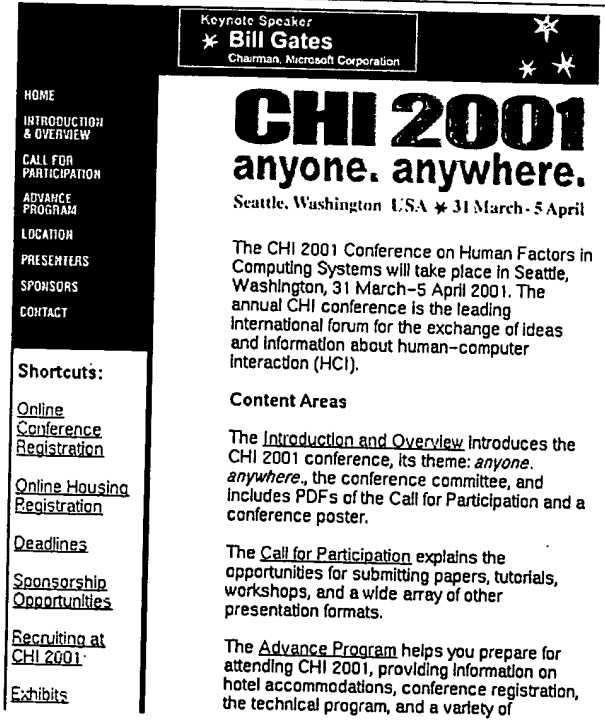

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Site Map (1)

Site Map

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Site Map (2)

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- Message Service
- Merchandise
- Policies

Accommodations
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- Conference Hotels
- Travel Information

Conference Registration
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- Registration Deadlines
- On-Site Registration

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- ACM SIGCHI Activities
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- Informal SIGS
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- Reception
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- Child Care and CHICamp

- Location: Seattle
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Introduction and Overview

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CHI 2001
anyone. anywhere.

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Introduction & Overview

The annual CHI conference is the leading international forum for the exchange of ideas and information about human-computer interaction (HCI). Diverse members of the global HCI community meet at the CHI conference to share the excitement of discovery and invention, to make and strengthen professional relationships and friendships, and to tackle real-world problems. Come to CHI 2001, and be part of laying the foundations of our discipline and identifying the challenges yet to be solved.

Topics
CHI 2001 invites submissions on the full range of HCI related topics, including but not limited to:

- Universal access and usability
- Portable, wearable, and wireless computing
- Internalization and implications of culture on design
- User profiling and individual differences between users
- Visions of HCI in the future
- New, integrative, or forward-looking perspectives on HCI
- Analysis, design, and evaluation methods
- HCI and its societal implications
- Theoretical foundations of HCI
- Devices and display systems, tools, and interaction techniques
- Critical reviews of HCI work
- Education about HCI
- Case studies and design briefings
- Guidelines and design heuristics

Participation Categories
The field of HCI includes many interests and perspectives on human-computer interaction. In order to serve this large,

What's New?

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What's New?

What's New at CHI 2001

CHI 2001 has extended a special invitation for submissions related to the conference theme: *anyone.anywhere*. See CHI 2001 Conference Special Areas for more information.

CHI 2001 has especially encouraged the submissions of groundbreaking basic research across the technical program. Recognizing the continuing need for establishing a research basis for investigations focused on enabling all users access to information technologies, CHI 2001 is committed to the inclusion of high quality, empirical investigations aimed at laying the groundwork for further research and development.

The CHI 2001 Development Consortium will focus on realizing the CHI 2001 goal of providing unique opportunities for bringing together diverse members of the global HCI community. This will be accomplished, in part, by the inclusion of Latin American researchers, designers, developers, and educators in the exchange of ideas, information, and accomplishments at CHI 2001 in Seattle.

CHI 2001 is revamping video submissions this year by eliminating video papers from the technical papers forum and video demos from the demos forum and introducing Interactive Video Posters. This new venue will enable highly interactive exchanges of ideas and breakthroughs in the community.

Acknowledging the plethora of employment opportunities within the CHI community and the need within our community to enhance communication between employers and potential employees, CHI 2001 will be providing special opportunities, including recruiting booths and the ability to reserve space for job announcements, in order to increase discussion and networking opportunities at the conference.

Conference Committee

CHI 2001 anyone. anywhere.

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Conference Committee

This is a listing of all of the CHI 2001 committee members and their contact information (including where to send submissions). If you would like to send feedback to the committee members, feel free to email to the address listed below or use the online feedback form.

Management

Conference & Technical Program Co-Chairs
Julie Jacko, *Georgia Institute of Technology*
Andrew Sears, *UMBC*
chi2001-chairs@acm.org

SIGCHI CMC Liaison
Kevin Schofield, *Microsoft Corporation*

ACM SIGCHI Program Director
Alisa Rivkin, *ACM*

Conference Manager
Paul Henning, *Conference & Logistics Consultants, Inc.*

Technical Program

Demonstrations Co-Chairs
Nancy Frishberg, *New Media Centers*
David Hamilton, *Connex, Inc.*
chi2001-demos@acm.org

Design Expo Co-Chairs
Johnathan Arnowitz, *Informaat*
Elizabeth Dykstra-Erickson, *Generic Media, Inc.*

Call for Participation

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Call for Participation

The CHI 2001 Call for Participation describes opportunities to participate in the conference, including twelve participation categories, sponsorship, exhibiting and volunteering at the conference.

Submitting to CHI: Process and Format describes the requirements for the Confence Publications Format, Electronic Submission requirements, and Poster Preparation guidelines. There is an online process for submitting Cover Pages, and a guide to successful submissions. Please also note the guidelines on video submissions.

The Regional Liaisons are there to help answer your questions about the submission process, and the conference in general.

Volunteering describes the many ways in which you can help at CHI2001. This includes mentoring someone through the submission process, as well as submission reviewer volunteering and student volunteers.

The CHI Mentoring program pairs people with experienced CHI authors to assist with the CHI publication process. Mentoring is available for first-time authors submitting tutorials, papers, short talks, interactive video posters, and student posters.

Sponsorship Opportunities are available which will demonstrate your organization's interest in and commitment to the field of HCI.

Participation Categories: The field of HCI includes many interests and perspectives on human-computer interaction. In order to serve this large, heterogeneous community, CHI 2001 invites technical submissions in 12 participation categories, including the new category of Interactive Video Posters. If you are unsure which category to submit to, please consult the

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Reviewer Volunteer Center

CHI 2001 Participation Categories
Volunteering to review for CHI 2001 is open:

- Tutorials: deadline was 3 June
- Papers: deadline was 18 July
- Short Talks and Interactive Posters, Student Posters: deadline is 1 October

About Your Profile
In order to volunteer as a reviewer, you will need to provide:

Contact information (address, telephone number, etc.)

Reviewing interests (ranking of topics you are willing to review)

Reviewing Background (your reviewing history)

CHI Reviewer Volunteer Center

Paper Reviewers: Go to Paper Reviewing Login for CHI 2001 at Microsoft to see what papers you have been assigned.

- You do not need to come here to the RVC for anything to do with papers anymore
- You have a **different password** for reviewing than what you got here for volunteering
- Contact chi2001-papers@acm.org if you need help

CHI 2001 is now accepting volunteers. CHI 2001 will be March 31 – April 5, 2001, Seattle, Washington, USA.

- Log in if you are already a member of the Reviewer Volunteer Center
- Sign up if you have not reviewed for the CHI Conference lately
- Get a reminder if you have forgotten how to log in

The CHI Reviewer Volunteer Center is where you can let us know what you are willing to review for the next CHI Conference. Various technical program chairs will review the set of volunteers and contact you if you are needed.

We know your time is valuable. We have worked hard to make the volunteering process as easy as possible. We need to know a lot about you (see left margin) in order to select a diverse set of reviewers. But we hope that providing this information is painless. Some user comments:

- "The site was so well thought out that registering to review was actually a pleasure!"
- "I survived it in less than ten minutes. I found the process clarifying and useful, both in terms of thinking about my role in the CHI community and in terms of thinking about my interests in both personal and broad terms."

Paper Submission

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Papers Co-Chairs:
Michel

Papers

Deadline: 8 September 2000

Papers present significant intellectual and technical contributions by researchers and practitioners to basic research, development, and practice in all areas of the field of human–computer interaction. Papers are presented at the CHI conference and are collected in an archival conference proceedings, which is published by ACM and cited and read by researchers, practitioners, and educators worldwide. A paper in the technical program can have wide impact on the study of HCI principles, theories, and techniques, and on their application to interactive systems practice. A Guide to Successful Papers Submissions is available. Mentoring for papers is also available for first-time authors. The deadline to request a Mentor is 9 June 2000.

Submission and Review Criteria
Paper submissions are reviewed rigorously by a large pool of volunteers drawn from the international technical community of HCI researchers and practitioners. The content and presentation of submitted papers must be acceptable as received. The review process attempts to ensure that papers are assessed rigorously and without bias by applying the same comprehensive set of criteria to every paper. Accordingly, all papers should be prepared with consideration of these criteria:

1. *Contribution to the field of HCI and impact or benefit to the field.* The contribution should be made clear in the abstract as well as the paper, outlining the direct significance to others in any area of the field of HCI. The contributions presented may be one of the following:

- a design for an interactive system that supports the needs of end users
- an interaction technique, device, or other component of

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Deadlines

Submissions Deadlines:

CHIkids	8 Sep 2000
Demonstrations	8 Sep 2000
Design Expo	8 Sep 2000
Development Consortium	8 Sep 2000
Doctoral Consortium	8 Sep 2000
Interactive Video Posters	8 Sep 2000
Panels	8 Sep 2000
Vision Statement:	14 Jul 2000
Final Submission:	8 Sep 2000
Papers	8 Sep 2000
Short Talks and Interactive Posters	8 Dec 2000
Special Interest Groups	8 Dec 2000
Student Posters	8 Dec 2000
Tutorials	28 Jul 2000
Workshops	8 Sep 2000

Volunteering Deadlines:

Student Volunteers	
Preliminary deadline:	8 Sep 2000
Final deadline:	26 Jan 2001

Requests for Mentoring Deadlines:

Papers	9 Jun 2000
Short Talks/Interactive Posters	29 Sep 2000

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Technical Program Overview

Demonstrations
Demonstrations offer an opportunity to show an innovative interface concept, HCI system, technique, or methodology. Attendees are able to view systems in action and discuss them with the people who created them.

New! Design Expo
A new event for CHI 2001, the Design Expo is a unique opportunity for designers to present new ideas and innovations to the CHI community. Designs will be presented in a moderator-discussant format. Authors will be available for questions.

New! Interactive Video Posters
This new venue will enable highly interactive exchanges of ideas and breakthroughs in the community because it combines the attributes of an interactive poster presentation with a video presentation.

Panels
Panels stimulate thought and discussion about ideas and issues of interest to the human-computer interaction community. Panels typically focus on controversial or emerging issues, allowing speakers and the audience to explore, debate, and reflect on these issues.

Papers
Papers present significant contributions by researchers and practitioners to the HCI field, capable of influencing the design lifecycle of current and future interactive systems. Papers are highly refereed and are published in the archival *CHI Conference Proceedings* and as an issue of *CHI Letters*.

Plenary Sessions
Plenary sessions are general sessions that open and close the

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Paper Categories

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Technical Program by Category: Papers

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Human Performance Points

Date: Tuesday, 3 April
Time: 11:30-13:00

Scale Effects In Steering Law Tasks: Do Device Size and

Paper Details

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The Write Stuff

Date: Wednesday, 4 April
Time: 16:30-18:00

Chinese Input with Keyboard and Eye Tracking - An Anatomical Study
Jingtao Wang, *IBM China Research Lab*
Shumin Zhai, *IBM Almaden Research Center*
Hui Su, *IBM China Research Lab*

Model for Unistroke Writing Time
Poika Isokoski, *University of Tampere*

Text Input for Mobile Devices: Comparing Model Prediction to Actual Performance
Christina James, Kelly Reischel, *Tegic Communications*

Communities and Collaboration

Date: Thursday, 5 April
Time: 9:00-10:30

Better Home Shopping or New Democracy? Evaluating Community Network Outcomes
John M. Caroll, Mary Beth Rosson, *Virginia Tech*

Identity Construction Environments: Supporting a Virtual Therapeutic Community of Pediatric Patients Undergoing Dialysis
Marina U. Bers, *MIT Media Lab*
Joseph Gonzalez-Heydrich, *Boston Children's Hospital*
David Ray DeMaso, *Boston Children's Hospital*

Geney: Designing a Collaborative Activity for the Palm Handheld Computer
Arman Danesh, Kori Inkpen, Felix Lau, Keith Shu, *Simon Fraser University*

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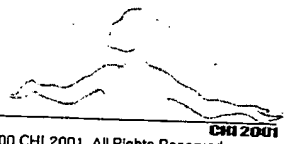

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Conference Hotels

Sheraton Seattle Hotel & Towers
Conference Headquarters Hotels
www.sheraton.com

The Sheraton Seattle Hotel and Towers is located in the city's vibrant core and next door to the Washington State Convention and Trade Center. A recently completed 14 million dollar renovation of the lobby, restaurants, guest rooms and suites combine refined urban style with touches of Northwest heritage. Club Level and Towers rooms offer unparalleled amenities, and the health club offers a spectacular view from the 35th floor.

US$159 Single/$179 Double
(Additional person $20.00)
Corporate Club Level
US$189 Single/$214 Double
(Additional person $25.00)

Mayflower Park
www.mayflowerpark.com

This elegant European style hotel is centrally located downtown and offers many personal amenities for your comfort and convenience.

US$135 Single/$150 Double

Paramount Hotel
www.westcoasthotels.com/paramount

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Travel Information

CHI 2001 will be held at the Washington State Convention and Trade Center, 800 Convention Place, Seattle, Washington 98101, USA.

For details on how to reach the Washington State Convention and Trade Center by car, please see www.wsctc.com. Follow the link to General Information/Directions.

Airline Discounts
Special discount airfares on Northwest Airlines and United Airlines have been arranged.

Rental Car Discounts
Avis and Alamo rental car companies will offer CHI 2001 attendees 10% discount off the applicable rental rates when reservations are made in conjunction with United Airlines air reservations. Please ask the reservationist for more information on car rentals when booking your airline ticket.

Public Transport
The use of public transportation rather than cars is strongly recommended. Cars can be hired at the airport, but their use within the city is strongly discouraged. All hotels are within walking distance to the Convention Center. Most all of downtown Seattle is within reasonable walking distance. Taxis are plentiful and fares within the city are reasonable.

Parking Facilities
The Washington State Convention and Trade Center has an underground car parking garage for those persons driving to the conference for less than US$20 per day. The hotels have parking facilities for hotel guests.

Airport Taxicabs
Taxicabs are available outside the airport terminal. Typical

Registration Overview

Keynote Speaker
★ Bill Gates
Chairman, Microsoft Corporation

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Shortcuts:

Go directly to secure on-line registration

Update your registration

CHI 2001
anyone. anywhere.
Seattle, Washington USA ★ 31 March - 5 April
On-Line Registration System

NOTE: Early registration rates are in effect through 15 February 2001. Rates are higher on 16 February and thereafter - so register now!

This on-line registration system is based on your use of a credit card to pay for your conference registration.

If you must pay by check, please download the order form which is stored in Adobe Acrobat format. You can also download the Adobe Acrobat Reader if you don't have it. Then fill out and mail your application form with payment to:

CHI 2001 Registration
c/o Registration Systems Lab
2060 Goldwater Court
Maitland, FL 32751 USA

Original Registration

IMPORTANT NOTE: **Your registration is NOT COMPLETE until you receive a page titled "CHI 2001 - Your Registration Acknowledgement"** This page will contain your five or six-digit Registration Number.

If you fill out the form and submit your order and nothing

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Registration for Tutorials

Tutorial Registration

What do the check-box captions mean?	UNITS	These are NOT real tutorials, just examples.	
An Available Tutorial	1	74 ☐ 65	<-- Tutorial Number <-- Check here to select this tutorial <-- Number of seats left
A Sold-Out Tutorial	1	75 sold out	<-- Tutorial Number <-- Sold out: <-- No space available.

If the tutorial you want is sold out, do not lose hope! There are occasional cancellations, and you can add tutorials on-site if they can also adjust your order on-line, if you observe that a tutorial becomes available.

Important: You may register for up to six tutorial units only. The on-line system will not let you register for tutorials or workshops

	UNITS												
Saturday Evening	1	1 ☐ 195											
Sunday Morning	1	2 ☐ 65	3 ☐ 67										
Sunday Full-day	2	4 ☐ 37	5 ☐ 39	6 ☐ 56	7 ☐ 114	8 ☐ 59	9 ☐ 60	10 ☐ 67	11 ☐ 66	12 ☐ 74	13 ☐ 71	14 ☐ 201	17 ☐ 201
Sunday Afternoon	1	15 ☐	16 ☐										

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Location

Seattle, Washington

CHI 2001 will take place in Seattle, Washington, the "Emerald City" of the Pacific Northwest. Seattle is nestled on a narrow strip of land between Puget Sound and beautiful Lake Washington. To the west are the jagged Olympic mountains and to the east are the volcanic peaks of the Cascade Range with snowcapped Mount Rainier. Seattle has always offered innovations in music, film, theater, and food and it is the jewel of the Northwest, with many exciting and interesting sites to be explored.

CHI 2001 will be held in the Washington State Convention and Trade Center, an award winning building designed to dramatically integrate the vitality of this international port city with the natural beauty of the Evergreen State. The Center is located at 800 Convention Place in the heart of the downtown area. The main conference hotel is the Seattle Sheraton located nearby at 1400 6th Avenue.

The Washington State Convention and Trade Center is twenty minutes from Seattle-Tacoma International Airport and just steps away from some of the city's finest hotels and restaurants.

Travel Information is available, as well as descriptions of a variety of Seattle attractions.

Attractions

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Ballard Locks
The Ballard Locks connect Puget Sound with the fresh water of Salmon Bay, Lake Washington, and Lake Union where you can watch vessels being raised and lowered. The locks also feature seven acres of botanical gardens and salmon fish ladders that can be seen from an underwater viewing window.

The Burke Museum
Enjoy spectacular artifacts and amazing specimens at the region's only and major natural history museum. The Burke Museum houses many interactive events and exhibits such as a rumbling volcano, real dinosaur skeletons, and an Ice Age mastodon.

The Experience Music Project
The Experience Music Project (EMP) is a one-of-a-kind music museum combining interactive and interpretive exhibits to tell the story of the creative, innovative, and rebellious expression that defines American popular music. This newly opened museum features a world-class collection of artifacts, unique architecture, state-of-the-art technology, exciting interactive presentations, and a dynamic ride-like attraction. EMP will encourage visitors of all ages and backgrounds to experience the power and joy of music in its many forms.

The Museum of Flight
The Museum of Flight showcases the history of aviation technology from its inception to the present. Exhibits are housed in the Red Barn, Boeing's first manufacturing plant, and in the glassed-in Great Gallery Complex located near Boeing field.

Pacific Science Center
Located under the arches near the Space Needle, the Pacific Science Center is a six-building complex offering hands-on

Material for Presenters

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Presenters

The following materials are available to those who will be presenting at CHI2001.

All materials are in PDF format, and require Adobe Acrobat Reader.

Author Kit for Demonstration Presenters
Overview
How to Produce a Camera Ready Document
How to Prepare for Presenting at the Conference
ACM/SIGCHI Technology Support Speaker Request Form
ACM Permission and Release Form

Author Kit for Design Expo Presenters
Overview
ACM Permission and Release Form
How to Produce a Camera Ready Document
How to Prepare for Presenting at the Conference
Permission and Release Form for Video/Audio Submissions

Author Kit for Development Consortium Presenters
Overview
ACM Permission and Release Form
How to Produce a Camera Ready Document
ACM/SIGCHI Technology Support Summary

Author Kit for Doctoral Consortium Presenters
Overview
ACM Permission and Release Form
How to Produce a Camera Ready Document
ACM/SIGCHI Technology Support Summary

Author Kit for Interactive Video Poster Presenters
Overview
ACM Permission and Release Form

Resources

Annotated Bibliography

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- The annotated bibliography for this tutorial is available to tutorial participants at the following URL:
  - http://dfki.de/~jameson/chi01-ttrl/
- The use of an electronic hypertext format permits
  - Inclusion of a large number of works
  - Rich indexing according to the concepts used in this tutorial
  - Access to electronic versions of works available on the web via a mouse click
- The bibliography is platform-independent
- It can be used directly on the web or downloaded to your own computer

Readings

Readings (1)

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The three readings reproduced here have been selected because

- Together, they give an idea of the nature of original literature in the area of user-adaptive systems
- They are exceptionally well written

Reading 1: De Bra et al. (1999)

De Bra, P., Brusilovsky, P., & Houben, G. (1999). Adaptive hypermedia: From systems to framework. *ACM Computing Surveys, 31*(4es).

Readings (2)

Reading 2: Maglio et al. (2000)

Maglio, P. P., Barrett, R., Campbell, C. S., & Selker, T. (2000). SUITOR: An attentive information system. In H. Lieberman (Ed.), *IUI 2000: International Conference on Intelligent User Interfaces* (pp. 169–176). New York: ACM.
http://lieber.www.media.mit.edu/people/lieber/IUI/

Reading 3: Segal and Kephart (1999)

Segal, R. B., & Kephart, J. O. (1999). MailCat: An intelligent assistant for organizing e-mail. *Proceedings of the Third International Conference on Autonomous Agents,* pp. 276–282.
http://www.research.ibm.com/swiftfile/

Note: MailCat was later renamed "SwiftFile"; it is the same system that has been discussed at some length in this tutorial